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A TEXT-BOOK

OF

ECONOMIC ZOÖLOGY

BY

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ILLUSTRATED WITH 237 ENGRAVINGS

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PREFACE.

The science of zoölogy is the science of the study of animals. One phase of that study is the relation of animals to man. This is a relation that is very complex, involving such diverse elements as: the animals that are used as beasts of burden; that furnish food and clothing; that are injurious to man himself, to his crops or his domestic animals. It involves also man's relation to the wild animals that live about him no matter whether the appeal is to one of the most primitive instincts, the spirit of the chase or whether it is an appeal to one of man's highest instincts, the appreciation of the æsthetic in Nature.

From the standpoint of general zoölogy many animals may be much more interesting than those which cause diseases or furnish food, clothing or ornaments, but from man's standpoint the latter are vastly more important. The present text-book is an attempt to furnish material for teaching the fundamental principles of zoölogy from this standpoint.

Science is systematized knowledge and the first duty of the science teacher is to systematize the knowledge that the student already possesses. The average student is more familiar with mammals and the other vertebrates than any other groups of animals. Therefore, the present text-book begins its discussion with these more familiar forms and leaves the least familiar forms until last. Thus we follow the principle of approaching a new subject by proceeding from the known to the unknown, reversing the familiar method in zoölogy texts of proceeding from the simple to the complex, morphologically speaking. Throughout, the stress has been placed on economic importance and the various phases of natural history rather than on morphology, believing that these are the phases of zoölogy that are most interesting and of the greatest importance to the student beginning his study of zoölogy.

No one person can be familiar with all the various aspects of so broad a field as general zoölogy. A text-book covering such a field

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is simply a mosaic of the ideas of investigators in the various fields. All that the author of such a text-book as this can hope to do is to arrange these ideas, the tiles of the mosaic, in a new pattern. The writer is indebted, therefore, to the authors of various text-books for the fundamental ideas here expressed.

Illustrations have been introduced in profusion because it is believed that if illustrations are carefully made and carefully studied they will give the student much more information in a much smaller space than the printed page can convey. Some of the illustrations have been borrowed from other sources which are fully acknowledged in the text. Others have been made by Miss Elizabeth Haban, to whom the author is under great obligation. Her skill in making illustrations is only exceeded by the patience with which she has labored to transfer the author's ideas into satisfactory drawings.

The author is also greatly indebted to the other members of the staff of the Department of Zoölogy of the North Carolina State College, Dr. L. H. Snyder, Dr. T. B. Mitchell and Professor F. B. Meacham, for many ideas and suggestions which have developed during the two years that the material in this text-book has been used in mimeographed form as a text-book in our general course in Zoölogy. Dr. C. L. Metcalf has also read the manuscript and made numerous suggestions.

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ECONOMIC ZOÖLOGY.

CHAPTER I.

THE MAMMALIA AND THEIR ECONOMIC IMPORTANCE.

- Characters
- Classification
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    - Beast of burden
    - Meat and milk
    - Leather and wool
    - Pets
    - Minor uses
  - Wild animals in relation to man
    - As pests
    - As destroyers of pests
    - As carriers of diseases
    - For food and sport
    - Furs
    - Whalebone and oil

CHARACTERS.

The class Mammalia includes besides our common domestic animals a number of familiar forms such as the opossum, the bats, the rats, the mice, the rabbits, the bears, the foxes, the deer, the whales, man and many other forms. About 7500 species are known from all parts of the world. Nearly one-third of this number occurs in North America alone.

The more important characteristics of the mammals may be tabulated as follows:

External Characters.—1. The skin is provided with sweat and sebaceous glands and a more or less complete covering of hair, fur or wool.

2. With the exception of the marine and strictly aquatic forms mammals are quadrupeds with the fingers and toes five or a reduction from five.

3. Mammary glands which secrete milk for the nourishment of the young are always present in the female.

4. The body is typically divided into head, neck, trunk and tail regions.

5. There is usually a pair of well-developed external ears sometimes absent as in the whales and in certain burrowing forms like the moles.

Internal Characters.—6. All mammals are warm-blooded, the temperature varying in different species from 77° F. to 104° F. (25° C. to 40° C.).

7. The heart is completely four-chambered and there is but one aortic arch, which curves to the left.

8. The red blood corpuscles are non-nucleated, circular in outline with the exception of the camels, where they are oval.

9. Respiration is carried on by lungs and the upper end of the trachea is modified into a larynx for the production of sound.

10. The thoracic cavity is separated from the abdominal cavity by a complete diaphragm.

11. There is usually a definite number of teeth, each tooth set in a separate socket. The teeth are frequently modified into three types; the incisors, canines and molars, and with few exceptions there are two sets, the milk teeth and the permanent teeth.

CLASSIFICATION.

The following outline of the classification of mammals will show the main groups and will be useful for reference. This table includes only the common North American forms with a few of the more conspicuous forms from other parts of the world.

Class Mammalia.

- **Sub-class Prototheria**—Egg-laying mammals.
  - Order Monotremata—The duckbill.
- **Sub-class Eutheria**—Viviparous mammals.
  - Division Didelphia—Pouched mammals.
    - Order Marsupialia—The opossums and the kangaroos.
  - Division Monodelphia.
    - Section Unguiculata—Clawed mammals.
      - Order Insectivora—Insect-eating mammals.
        - Family Talpidæ—Moles.
          - Soricidæ—Shrews.
      - Order Chiroptera—Flying mammals: bats.
      - Order Rodentia—Gnawing mammals.
        - Family Sciuridæ—The squirrels.
          - Geomyidæ—Pocket-gophers.
          - Heteromiydæ—Pocket mice, kangaroo rats.
          - Castoridæ—Beavers.
          - Muroidea—Mice and rats.
          - Leporidæ—Hares and rabbits.
          - Hystricidæ—Porcupines.
          - Chinchillidæ—Chinchilla.
          - Caviidæ—Guinea-pigs.
      - Order Carnivora—Flesh eaters.
        - Family Ursidæ—Bears.
          - Procyonidæ—Raccoons.

Order Carnivora—Family Mustelidæ—Martens, weasels, wolverines, otters, skunks, badgers, mink.
Canidæ—Wolves, foxes, dogs.
Felidæ—Cats, lions, tigers.
Hyænidæ—Hyenas.
Order Pinnipedia—Aquatic mammals.
Family Otariidæ—Eared seal, fur seal, sea-lion.
Phocidæ—Harbor seal.
Odobenidæ—Walruses.
Order Edentata—The toothless mammals.
Family Bradypodidæ—Three-toed sloths.
Myrmecophagidæ—Ant-eaters.
Dasypodidæ—Armadillos.
Section Ungulata—Hoofed mammals.
Order Artiodactyla—Even-toed mammals.
Family Hippopotamidæ—Hippopotamus.
Suidæ—Swine.
Tayassuidæ—Peccaries.
Cervidæ—Deer, elk, moose, reindeer.
Antilocapridæ—Pronghorn.
Bovidæ—Bison, musk-ox, cow, sheep, goat, bighorn, gazelle, antelope.
Camelidæ—Camels, llama.
Giraffidæ—Giraffe.
Order Perissodactyla—Odd-toed mammals.
Family Tapiridæ—Tapirs.
Equidæ—Horse, ass, zebra.
Rhinocerotidæ—Rhinoceros.
Order Proboscidea—Elephants.
Order Sirenia—Sea-cow.
Section Cetacea—Marine mammals.
Order Odontoceti—Toothed whale.
Family Physeteridæ—Sperm whale.
Delphinidæ—Porpoise, narwhal, killer whale.
Order Mystacoceti—Whalebone whales.
Family Balænidæ—Right whale.
Balænopteridæ—Finback whale, sulphur-bottom whale.
Section Primates—Nailed mammals.
Order Primates.
Family Lemuridæ—Lemurs.
Cebidæ—American monkeys.
Cercopithecidæ—Old World monkeys.
Simiidæ—Apes.
Hominidæ—Man.

A BRIEF DISCUSSION OF SOME COMMON MAMMALS.

The mammals are divided into two sub-classes. The first sub-class (Prototheria consisting of a single order Monotremata) includes the mammals which lay eggs resembling reptile eggs, deposited either in a pouch on the mother's abdomen as in the spiny ant-eater, or in a tunnel in the ground as in the duckbill. After the eggs hatch the young are nourished by milk secreted by the mammary glands, which are not provided with teats, the young simply lapping up the milk as it is secreted. The duckbill (Fig. 1) or duck mole of Australia, *Ornithorhynchus anatinus*, is a burrowing aquatic animal with a peculiar bill-like snout and webbed fore feet. It is about 1½ feet long and feeds on worms which it digs out of the soft mud with its peculiar bill. The spiny ant-eater or porcupine ant-eater, to distinguish it from the other ant-eaters, is a small mammal about 1 foot long with compact body and short, powerful limbs. The head is drawn out into a narrow proboscis and the tongue is elongate and is protruded for picking up ants and other small insects. The back is covered with short, blunt spines.

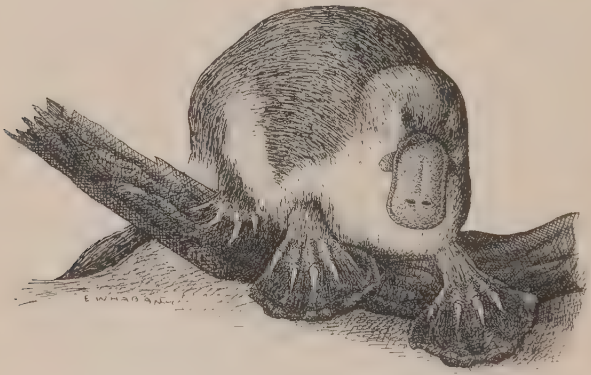


FIG. 1.—The duckbill. *Ornithorhynchus anatinus.*

The second sub-class (Eutheria) includes the mammals which produce living young. It includes two divisions, the Marsupials or pouched mammals (Didelphia), and the placental mammals (Monodelphia). The marsupial division includes those mammals which have no well-developed placenta. The young are therefore, born in a very immature state and are placed in a pouch on the abdomen of the mother, where they are nourished on milk until they can shift for themselves. This group reaches its greatest development in Australia. Here we have not only the true kangaroos, *Macropus spp.*, with their weakly developed fore limbs and powerfully developed hind limbs and tail, their peculiar upright posture and leaping locomotion; but many other forms of marsupials which have paralleled the development of mammals in other regions of the world. There are for example peculiar bear-like marsupials like the koala, *Phascolarctos cinereus;* peculiar squirrel-like marsupials like the flying phalangers and the so-called sugar squirrels, *Petaurus spp.;* the rabbit-like bandicoots, *Peragale spp.*, with long ears and short tail; the mole-like burrowing marsupial mole and the rat-like kangaroo rats which are nearly as big as rabbits with rat-shaped heads and long, nearly naked tails. There are also dog- or wolf-like forms called zebra wolves, *Thylacinus cynocephalus,* with striped bodies and wolf-like heads, which are carnivorous.

The marsupials are also well-developed in South America where we have rat-like and mouse-like forms. The latter are sometimes shipped to this country in bunches of bananas.

In North America north of Mexico, we have but a single genus of pouched mammals; the opossums, which are well represented by our common eastern opossum, *Didelphis virginiana.* This animal is about the size of the common cat. The tail is long and scaly like a rat and the fur is dirty yellowish-white in color. Ten or a dozen young are born at a time and placed in the pouch of the mother.

The placental mammals have a well-developed placenta for the nourishment of the embryo and its attachment to the wall of the uterus of the mother. While the young are often born in a helpless state they are well-developed and are never placed in a pouch. This division comprises four groups: The marine mammals (Cetacea), the mammals with claws (Unguiculata), the mammals with hoofs (Ungulata) and the mammals with nails (Primates).

The marine mammals or whales are often confused with the fishes because they are strictly aquatic and never occur on land. They are, however, true mammals, and have the usual characters of the mammals, that is, they are warm-blooded vertebrates that breathe by means of lungs, that have some hair on the body, never any scales, and the young are born alive and nourished by means of milk just like the land mammals. The body of the whale is modified for its aquatic existence. The general form is somewhat spindle-shape or fish-like. The neck is short and not clearly differentiated from the head and trunk. The trunk is elongate, tapering posteriorly. The hind limbs are wanting and the fore limbs are developed as fin-like flippers. The tail consists of two horizontal flukes and is the principal swimming organ. The whales are the largest of mammals, reaching a length of 60 feet or more, although some of the smaller whales are only 10 to 20 feet long.

This group is divided into two orders, the toothed whales (Odontoceti) and the whalebone whales (Mystacoceti). The former order includes those whales with teeth in the lower jaw, sometimes in the upper jaw also. This order includes the sperm whale, the largest toothed whale, often reaching a length of 75 feet. It was formerly taken in large numbers for its fine oil. Ambergris, which is used in the manufacture of perfume, is a secretion of the stomach of the sperm whale. The porpoises, *Family Delphinidæ,* are small whales common along the Atlantic Coast where they feed in the breakers near shore and are often mistaken for sharks. In the narwhal, *Monodon monoceros,* the male has a single tusk which develops as a long twisted projection, often 10 feet long. It is used as a weapon of offense and defense.

In the whalebone whales the teeth are replaced by elongate plates of baleen or whalebone which act as a strainer in removing from the sea water the small marine animals on which these whales feed. Whalebone was formerly an important article of commerce, being used extensively in the manufacture of whips, stays and similar flexible articles. The largest species of this order is the sulphur-bottom whale which may be nearly 100 feet long. Other species are known as right whale, fin back, gray whale and humpback. They average from 40 to 70 feet in length.

The mammals with claws include five common orders, the insect-eating mammals (Insectivora), the flying mammals or bats (Chiroptera), the toothless mammals (Edentata), the rodents (Rodentia) and the flesh-eating mammals (Carnivora).

The order Insectivora includes the common mole, *Scalopus aquaticus,* the hairy-tailed mole, *Parascalops breweri,* and the star-nosed mole, *Condylura cristata,* the shrews and the short-tailed shrews. The moles are burrowing mammals and their long tunnels in gardens and lawns are familiar to everyone. The body of the mole is short and compact. The forelegs are short and powerful with large hands adapted to digging. The mole lives principally upon insects but may be very destructive to lawns and gardens.

The shrews are small mouse-like mammals with conical heads and reduced ears and eyes. They are chiefly nocturnal and feed on insects, although seeds and the flesh of birds and mammals are frequently eaten. These little mammals are widely distributed and are often abundant in North America, especially northward and in the higher mountains, but because of the small size and retiring habits they are seldom noticed.

The order Chiroptera includes a large number of species of bats (Fig. 2). These small flying mammals are familiar to everyone. The bodies are somewhat mouse-like. The forelimbs are modified into wings by means of a thin membrane which is stretched between the elongate fingers and between the upper arm, forearm, trunk and hind limbs. The toes are usually developed for grasping and support the bats when at rest. Bats are very expert on the wing, darting in a rapid wavering flight and catching insects while on the wing. The young cling to the fur of the ventral side of the mother until they are able to shift for themselves. Only one is developed at a time.

The toothless mammals (Order Edentata) are not, strictly speaking, without teeth but have the teeth wanting from the front part of both the upper and lower jaws at least, and the back teeth either wanting or reduced. This group is chiefly tropical in its distribution. It includes the sloths, the giant ant-eaters and the armadillos. The armadillos, *Dasypus spp.* (Fig. 3) are the only forms found North of Mexico. They have a small head, an elongate tail and a body protected dorsally by bony plates. When disturbed by enemies they can roll themselves into a ball like a pill bug. They have the peculiar habit of producing their young as quadruplets. All four young produced at a given time develop from a single

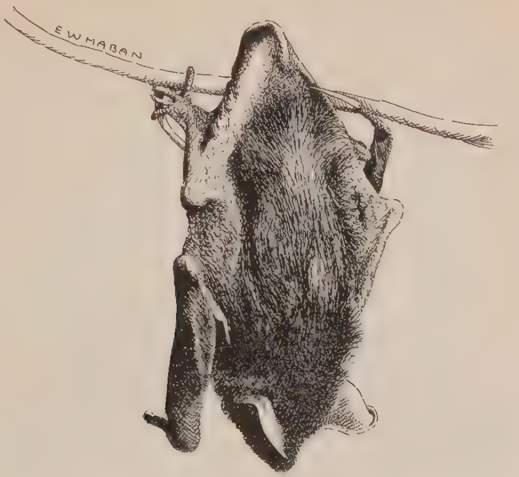


Fig. 2.—Brown bat. *Myotis lucifugus.* Sleeping.

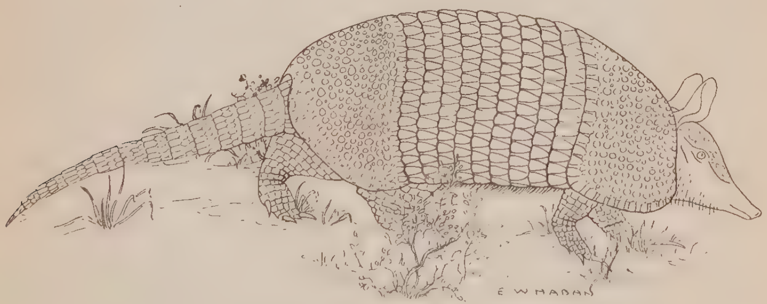


Fig. 3.—Nine-banded armadillo. *Dasypus novemcinctus.*

fertilized egg. The sloths are inhabitants of Central and South America. They are entirely arboreal living, moving and sleeping suspended from the limbs of trees; and feeding on leaves. Their slowness of movements is proverbial and has given us the word slothful.

The true ant-eaters, *Family Myrmecophagidæ,* (Fig. 4), are animals with the head prolonged into a long narrow beak with a small tubular mouth opening, through which the long tongue may be protruded to pick up ants or other small insects. Teeth are entirely absent. These animals are found in Central and South America.

The rodents or gnawers, Order Rodentia, are mammals in which the incisor teeth have been developed for gnawing. This is one of the largest of the orders of mammals. Most of the forms are familiar to everyone. A roll-call of the familiar forms would include, the woodchucks or ground-hogs, the ground squirrels, the prairie dogs, the chipmunks, the squirrels, the flying squirrels, the pocket-gophers, the pocket mice, the kangaroo rats, the beavers, harvest mice, white-footed mice, the rice rats, the cotton rats, wood rats, the collared lemmings, the voles, the meadow mice, the muskrat, the house rat, the house mouse, the jumping mice, the porcupines, the guinea-pigs, the hares, the rabbits and the cottontails.

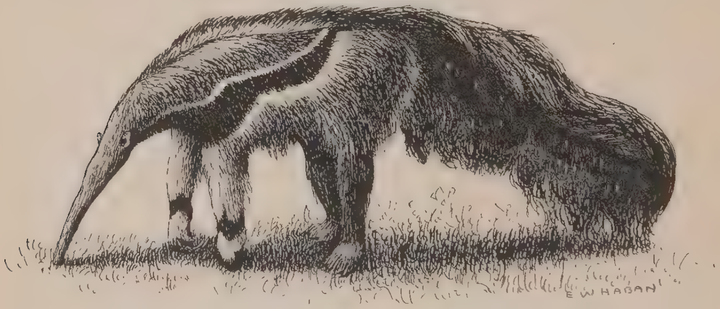


Fig. 4.—Great ant-eater. *Myrmecophaga jubata.*

The woodchuck, *Marmota monax* (Fig. 5), or ground-hog is a heavy bodied, burrowing mammal. Their burrows may be made in the woods or open fields and the dirt that is removed is piled near the entrance. The burrows sometimes extend into the ground for 25 feet or more and frequently have two entrances. The woodchuck hibernates over winter in its burrow and the half dozen young are born early in the spring. These animals feed on clover, grass and other vegetation and are frequently destructive to cultivated crops. They may be controlled by fumigating their burrows with carbon bisulphide or calcium cyanide.

The ground squirrels, *Callospermophilus spp.*, are burrowing mammals somewhat squirrel-like in form but closely related to the woodchuck. They are chiefly western in their distribution. The striped ground squirrel occurs in the great Mississippi Basin and the California ground squirrel on the Pacific Coast. These squirrels live in open fields or in bushy thickets and dig shallow burrows. They eat almost anything that comes their way and are sometimes destructive to grain fields.

The so-called prairie dogs, *Cynomys spp.*, are heavy-bodied, burrowing mammals characteristic of the Great Plains region west of the Mississippi River. They range westward through the mountains and southward into Mexico. These animals are chiefly diurnal in habits and gregarious, with their burrows often closely crowded together in prairie-dog villages or towns. The burrows are usually quite extensive frequently being 25 to 30 feet or more in length. The prairie dogs usually destroy the grass in and around a village, hence they are troublesome to ranchers.

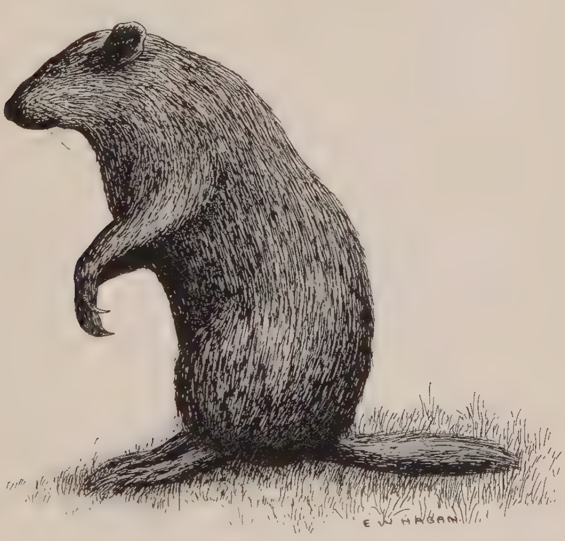


Fig. 5.—Ground-hog. *Marmota monax.*

The chipmunks, *Tamias striatus*, are a group of small squirrels that live on the ground and construct burrows in the ground. Their tails are short and not bushy and the body is provided with lateral pale stripes that are bordered with darker. These are active creatures that prefer open woodlands and considerable sunshine. Their burrows are usually about a foot in depth and may be several feet in length. The dirt from the burrow is usually moved to some little distance from the entrance. They feed principally on seeds and nuts which they store in convenient places. They hibernate during the winter but are frequently seen during spells of warm weather.

The squirrels are arboreal mammals with well-developed claws for climbing, powerful hind limbs for leaping and well-developed bushy tails which act like parachutes in leaping from tree to tree. As a general rule squirrels spend most of their time in trees building their nests of twigs, leaves and roots in hollow trees or knot holes, or among the branches. They come to the ground in search of food which consists chiefly of seeds and nuts. Some squirrels, especially the red squirrels, are not adverse to eating mushrooms, birds' eggs, young birds or mice. Our more familiar North American species include the red squirrel, the gray squirrel, the fox squirrel, the Douglass squirrel, and the Abert squirrel. The red squirrel, *Sciurus hudsonicus,* is more northern in its range, ranging southward through the Alleghany and Rocky Mountains. It is a small-sized squirrel, rusty red above and whitish below. The Douglass squirrel, *Sciurus douglasi,* is the western representative of the red squirrel. It is found generally in the Pacific Coast States. It is darker above and rusty red beneath.

The gray squirrel, *Sciurus carolinensis,* is more southern in its distribution than the red squirrel and ranges throughout the eastern United States to the Great Plains. It is usually gray above with the fringe of the tail and the under parts lighter. There is also a black phase which is generally known as the black squirrel and is nearly uniformly black. This squirrel has been very successful in adapting itself to the advancement of civilization and is able to maintain itself in parks and other wooded areas even in the heart of large cities and towns.

The fox squirrel, *Sciurus niger,* is the largest of our eastern squirrels. It varies much in color, some forms being quite yellow while other forms are darker, marked with rusty red below and other forms are dark gray or almost black.

The Abert squirrel, *Sciurus aberti,* and related forms of the Rocky Mountain region are strikingly beautiful squirrels with long ears and bushy tails. The body color is dark gray with a broad stripe of rusty red down the back. The bushy tail has a dark center and a broad white fringe. They live principally on pine seeds.

The flying squirrel, *Sciuropterus volans,* is a relatively small squirrel with a small round head, large eyes, small rounded ears and broad, flat tail. The color is brown above and whitish below. Stretched between the legs on each side of the body is an expansion of the skin. This enables these animals to make long, gliding leaps through the air. They do not fly in the sense that a bat or a bird flies but simply glide from a higher limb to a lower limb. The flying squirrel is abundant throughout the wooded areas of the United States and Canada. It is nocturnal in its habits and is seldom seen. It makes its nest in natural cavities or woodpecker holes. The flying squirrel is an omnivorous feeder, eating seeds, nuts, acorns, insects, birds' eggs and the flesh of birds and mammals.

The pocket-gophers, *Family Geomyidæ*, are represented by a number of species which occur in the western part of North America, ranging eastward to Georgia and Florida. They are thick-bodied animals, varying in size from that of a large mouse to that of a large rat, with small eyes and ears and a short tail, with powerful forelegs fitted for digging, and strong incisor teeth. The most peculiar structures are the large cheek pouches which this animal uses to gather its food which consists chiefly of tubers, roots and seeds. It is frequently destructive to potato fields and other crops. As a burrowing animal it is the equal of the mole, constructing much-branched tunnels from ½ to 1 foot or more below the surface. These tunnels are constructed in an aimless manner and are often several hundred yards long. The gopher is constantly extending its tunnels, the new earth excavated being pushed to the surface in little mounds.

The pocket mice, *Perognathus spp.*, and the kangaroo rats, *Parodipus spp.*, are related to the pocket-gophers. Both groups are characteristic of the arid regions of the West and Mexico. The pocket mice are small mouse-like creatures with cheek pouches like the gophers, and long tails, bushy at the tips. The kangaroo rats, as their name implies, are rat-like creatures with the long tails and powerful hind limbs of the kangaroo. They construct elaborate tunnels, often grouped in colonies, in which they live during the day and in which they store their food, which consists chiefly of seeds.

The beaver, *Castor canadensis* (Fig. 6), formerly occurred widely distributed over North America north of the Rio Grande and the Gulf. As civilization advanced the beaver retreated and today is found only in isolated areas far from civilization. The beaver is a heavily built animal, the largest of the North American rodents, averaging nearly 3½ feet in length. The hind feet are webbed and the tail is broad, flat and naked. The covering consists of long, coarse hair with a fine, short, silky under fur of a beautiful dark brown color, making it one of the prized furs. The habits of the beaver in damming small streams and their supposed intelligence and industry are well known. Both of the latter characteristics have been exaggerated, however, and to work like a beaver does not mean to work any harder than any other wild animal works to maintain itself and feed and raise a family. Those who have visited beaver colonies and examined them carefully state that the beaver's intelligence has been greatly over-rated. Their dams are remarkable examples of skill in construction, being skilfully bent against the current and reënforced with logs and stones and plastered with mud, but are frequently poorly located. Their reputed habit of cutting trees so that they will fall only in the open and toward the water is disproven by numerous lodged trees or trees that have fallen away from the water. After the dams are built and the pond is full of water the beavers build a low conical house of sticks and mud. In these houses there is a large central chamber in which the family lives. The beaver lives on bark and roots and lays up a store to provide against the long days of winter.

The introduced rats and mice are discussed in another connection. In addition to these forms, however, there are a large number of wild or field mice and rats. Space is not available here for the discussion of each species in detail as more than 75 species are known from North America alone. However, for convenience they may be grouped as field mice, meadow mice and field rats. The first of these groups would include wild mice resembling in a general way the common house mouse with slender bodies and relatively long tails. They are of very diverse habits and live in fields, woods, along the beach, in swamps and in the desert. The meadow mouse group consists of those forms that have heavy thick-set bodies and short tails. They live in meadows and woods and the lemmings which would fall here range as far northward as there is food available. The banded lemming is pure white in color in winter and brownish in summer. In spite of their natural enemies these little animals are usually abundant and at times of especial abundance they migrate in vast hordes crossing streams and passing over or around other obstructions that occur in their way. Needless to

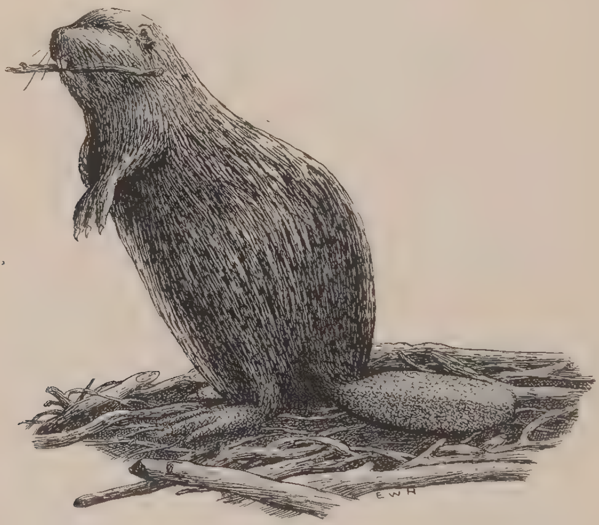


Fig. 6.—Beaver. *Castor canadensis.*

say many are destroyed during such migrations. The meadow mice often become very abundant in fields and are destructive to grain crops. The field rats in appearance are simply large-sized field mice.

The wood rat, *Neotoma pennsylvanica*, as its name implies, lives in the woods throughout the eastern United States. The cotton rat, *Sigmodon hispidus*, and the rice field rat, *Oryzomys palustris*, occur rather generally in the southeastern United States. The former more generally in waste places along ditch banks and the edges of fields. The latter more abundantly in rice fields, swamps and marshes.

The muskrat, *Fiber zibethicus* (Fig. 7), is a familiar inhabitant of streams, ponds and swamps. It constructs burrows in the bank and in swamps builds conical houses of mud, cattail leaves and stems and lined with cattail down or soft grasses, in which the family is raised and in which they live during the winter. The fur of the muskrat is much esteemed and they make up the bulk of our trade in fur, not only in numbers but in value also. The flesh is also valued and usually sold on the eastern markets as marsh rabbits. Muskrats eat a wide variety of food, including the river mussel, the roots of water lilies, splatter dock, turnips and grains, especially corn if grown near a swamp. Large areas of our eastern swamps are suitable for muskrat farming and could be made to yield a fair return if properly handled.

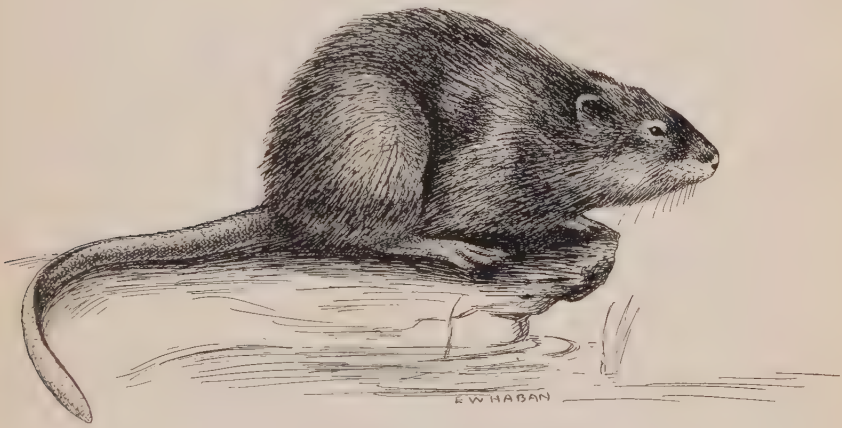


FIG. 7.—Muskrat. *Fiber zibethicus.*

The porcupine, *Erethizon dorsatum*, is a northern animal occurring commonly in the northern United States and Canada, and ranging southward to the mountains of Virginia, Texas and Arizona. Some of the hair on the back and tail is replaced by sharp spines which the animal uses as weapons of offense and defense. If the porcupine is attacked it erects the spines by arching the back and woe to the animal that ventures within reach of the lashing tail, as the sharp spines are driven into the flesh and make painful sores. The porcupine does not shoot the quills, however. The porcupine is chiefly a nocturnal solitary animal living in the woods and feeding on bark, fruits, nuts, etc. They can climb with ease but seem to spend much time on the ground.

The guinea-pigs, *Cavia porcellus*, are familiar South American rodents that have been extensively kept as pets and used for experimental and laboratory purposes. They are short-bodied, tailless creatures. In captivity they are perhaps our most prolific mammal, producing large litters and breeding almost continuously.

The *Family Leporidæ* includes the hares, rabbits, jack rabbits, cottontails and rock rabbit. It is an interesting group. Most of the members are used for food or furnish an ever abundant source of small game. The Arctic or polar hare, *Lepus arcticus*, occurs in the northern part of North America. It is pure white in color with the ears and nose tipped with black. The varying hare or snowshoe rabbit, *Lepus americanus*, occurs in Canada and the northern United States. It is almost pure white in winter and brown in summer.

The jack rabbits, *Lepus spp.*, of the western plains and mountain regions are famous for their long ears, long legs and speed. They vary considerably in color in the different species, some being dark gray while those living on the white sand of the desert are largely white and pale yellowish-brown. Jack rabbits are still abundant throughout most of their range, although large numbers are killed for sport, by automobiles and in sporadic rabbit drives when they become excessively abundant and destructive to crops. Jack rabbits, like the other hares, do not burrow but build forms in dense grass, where the young are born.

The cottontails, *Sylvilagus spp.*, are widely distributed in this country, various species occurring from the Atlantic to the Pacific and from southern Canada to southern Mexico. They are grizzly gray above and whitish below with the under parts of the tail pure white. Cottontails are dear to the heart of the country boy and are trapped and shot for food and furnish sport to more people than any other North American game animal. The cottontail digs its own burrow or lives in the burrows of other animals like the woodchuck. Several litters are produced during the spring and summer. The young are born blind and helpless and are placed either in the burrows or in forms above ground which are lined with grass and the fur of the mother. In the Southeastern and Gulf States there are two rabbits related to the cottontail that are semiaquatic in their habits. They are known as marsh rabbits and swamp rabbits. Both forms are good swimmers and are said to have the habit of concealing themselves in the water with the tip of the nose protruding so that they can breathe.

The rock rabbits or pikas, *Family Ochotonidæ*, are small tailless animals with short ears and legs. A superficial examination would seem to indicate that they were more nearly related to the guinea-pigs than to the rabbits. They occur throughout western North America from Alaska to Mexico and live among the rocks, mainly above timber line.

The chinchilla, *Chinchilla lanigera,* is a South American animal much valued for its fur. It resembles somewhat a cross between a squirrel and a pika, with rounded ears and a bushy tail.

The order Carnivora includes the common flesh-eating mammals which have the canine teeth well-developed and the premolars usually conical, developed for tearing flesh. The order may be divided into two sub-orders, the terrestrial carnivora (Fissipedia), which have the feet adapted for walking, and the aquatic carnivora (Pinnipedia), which have the feet developed as flippers for swimming.

The common North American raccoon or coon, *Procyon lotor,* belongs to the former sub-order. It is a small mammal much hunted for its fur and flesh which is used for food. This sub-order also includes the bears, which are large mammals with short tails. The black bear, *Euarctos americanus,* has a wide distribution in the United States and is generally well known. The larger grizzly bear, *Ursus horribilis,* of the Rocky Mountain region, is grizzly brown in color. The polar bear, *Thalarctos maritimus,* of the Arctic region is pure white in color. Bears are omnivorous creatures, feeding on flesh, insects, honey and a wide variety of fruits.

The *Family Mustellidæ* includes the fishers, the martens, the minks, the weasels, the ferrets, the wolverines, the otters, the skunks and the badgers. Many of these forms furnish valuable furs and are generally well known. All of them have well-developed scent glands which were perhaps developed to attract the opposite sex, but in the skunks they have been developed into effective weapons of defense. Some of the animals of this group are exceptionally blood-thirsty and often kill apparently for the joy of killing, as they kill more than they can devour.

The fisher, *Mustela pennanti,* is the largest member of the mink family in North America. It occurs in woodlands in Canada and the northern United States, ranging South in the higher mountains. It is a swift and agile animal, almost equally at home among the branches of trees or on the ground.

The marten, *Mustela americana,* is another cat-like weasel with yellowish-brown fur with the face and under parts including the tail, blackish-brown. It is one of the handsomest of our North American mammals. It lives in the pine woods of the northern United States and Canada and is closely related to the European sable. Both of these animals are much prized for their rich fur and have been hunted almost to the point of extinction.

The mink, *Putorius vison*, is another of the weasel family whose dark brown or blackish fur is highly valued. The body is long and slender and the tail is shorter than the body. The mink feeds on a long list of animals and seems to be equally at home on the land or in the water. It frequently becomes destructive to poultry and is a pest of game birds of first importance. The ferret is an African species which has been bred as an albino and is sometimes used to drive rats from their burrows about buildings.

The weasels, *Subfamily Mustelinæ*, are animals with a circumpolar distribution. The different species occur throughout North America, but weasels are more abundant in the higher mountains. Their bodies are long, slender and snake-like. In general, they are reddish-brown above and whitish beneath. In the northern part of their range, weasels become pure white or white with black-tipped tails. Weasels, like the other members of the family are ferocious hunting animals. They live principally on other mammals and birds and are frequently very destructive to poultry.

The wolverine, *Gulo luscus*, is one of the larger members of the weasel family. It formerly occurred throughout the wooded areas of Canada and southward into the northern United States. It was so destructive to animals of all kinds and especially to animals that had been caught in traps that it has been practically exterminated save in the more remote regions.

The skunks, *Subfamily Mephitinæ*, are widely distributed in North America and as they are bold conspicuous animals with powerful scent glands, they are generally well known. The common skunk, *Mephitis putida*, is generally distributed in North America from the Atlantic to the Pacific and from the Hudson Bay region to Central America. It varies greatly in color but a typical example would be black in color with the nape white and two broad lateral white stripes extending to the base of the tail. The little spotted skunks, *Spilogale spp.*, are found throughout the Southern States and then southward to Central America. They are black with irregular elongate spots of white. Our skunks feed for the most part on insects and mice and are therefore, valuable to the farmer. Occasionally they are destructive to chickens but the good that they do by destroying farm pests far outweighs the damage they do to poultry, game birds and insect-eating birds. Skunks should be protected from indiscriminate slaughter, not only because of their value as insect destroyers, but also because they are valuable fur-bearing animals.

Otters, *Lutra canadensis* (Fig. 8), may be described as large aquatic weasels. They live usually in the bank of a stream, protected by overhanging roots or a ledge or rock. They are more at home in the water, however, and feed extensively on fish, which they capture by outswimming. The fur is much prized and otters have been persistently hunted but seem to be able to maintain themselves over most of their former range, but since otters are solitary animals they are seldom observed.

The badger, *Taxidea taxus*, is an animal of the Great Plains region. It feeds chiefly on rodents and is, therefore, of value to the farmer. It is a thick-set, heavy-bodied animal that lives in burrows that it digs for itself. It is so strictly nocturnal in its habits that it may be abundant in a region without being observed.

The *Family Canidæ* includes not only the domestic dog but the fox, the coyote and the wolves. Most of the members of this family are of fairly large size and so familiar that the family characteristics need not be described. The domestic dog is discussed later under domestic animals (see page 46), but a brief description of the other common American forms will be given.

The foxes are noted for their intelligence and many tales have been told of their cunning in out-witting hunter, trapper and dogs. They dig burrows or construct dens in rocky hillsides where the young are raised. The bill of fare of the fox includes many small mammals, especially field mice, birds and insects. Occasionally they are destructive to poultry but as the foxes hunt chiefly at night, properly constructed poultry houses would prevent this loss. From the standpoint of the farmer, therefore, foxes are perhaps deserving of a measure of protection, although any great increase in numbers might lead to destruction of large numbers of game birds. For convenience of discussion our foxes may be divided into four groups: The red fox, the gray fox, the kit fox, and the Arctic fox.

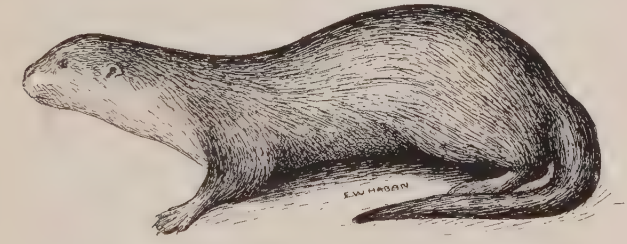


FIG. 8.—Otter. *Lutra canadensis.*

The red fox, *Vulpes fulva*, is more northern in its distribution, occurring from the limits of tree growth southward through the mountains to Georgia and New Mexico but absent from the Great Plains region. The cross fox, which has a black stripe across the nape and down the back, the silver fox which is blackish with silver gray hairs, the black fox which is black with a white tip to the tail are color varieties of the red fox which are valued for their fur.

The gray fox, *Urocyon cinereoargenteus*, has the upper parts and face grizzly gray, the sides of the neck, body and legs yellowish-red.

It is generally more southern in its distribution than the red fox. In general, their habits are the same as the red fox except that they do not dig tunnels but make their dens among rocks. In regions where both foxes occur the red fox is generally credited with the greater intelligence.

The kit fox, *Vulpes velox*, and its relative, the desert fox are smaller than the red and gray fox. They are light sandy yellow in color and look like they were faded. The kit fox occupies the northern part of the Great Plains, while the desert fox is found throughout the arid Southwest.

The Arctic fox, *Alopex lagopus*, as its name implies, lives in the Arctic region. In summer the fur of the upper parts is brownish or bluish-gray and in the winter pure white. The greater proportion of the Arctic fox's food consists of the lemming and it is said to bury them in holes in the ground while they are abundant to tide over times of scarcity.

The different species of coyotes or prairie wolves, *Canis spp.*, differ considerably in color, some being light gray and others yellowish-gray. They average larger than foxes and are not generally credited with being as shrewd as foxes. Yet in spite of continuous hunting, trapping and poisoning they seem to be able to hold their own. They are very destructive to poultry, game and live stock. Coyotes dig their dens or live among rocks like the red fox.

The wolf is larger than the coyote. The color varies considerably in different species and races and ranges from the pure white of the Arctic wolf, *Canis tundrarum*, through the grizzly gray and rufous gray to the blackish-gray of the timber wolf, *Canis gigas*, and to the pure black of the black wolf. Wolves, because of their large size, fearlessness and the fact that they often hunt in packs, often do much damage to live stock and game. They are, therefore, hunted and are gradually being exterminated over most of their range which formerly included most of North America.

The cat family, *Felidæ*, includes many familiar mammals, such as the domestic cat, the lion, the tiger, the leopard, the mountain lion, the lynx or bobcat, the ocelot and the jaguar. In general, all these cats resemble the common house cat in form and character, differing chiefly from this cat in size and color. The cat family includes some of the largest, most powerful and dangerous mammals. Of them it may be truthfully said that they live by tooth and claw. And the highest praise that can be bestowed upon a fighting dog is to assert that he can lick his own weight in wildcats. The wise dog, however, is the one that avoids a finish fight with wild or tame cats, either of equal size or smaller.

One of the largest of the cat family is the lion, *Felis leo*, the king of beasts. Now largely confined to the continent of Africa, it formerly ranged eastward in Asia to India. Those who have studied the lion in his native haunts assert that his courage has been vastly exaggerated and that in the daytime he is a lazy, cowardly beast and prefers to slink away except when cornered or wounded. However, the adult male lion with fully-developed mane still looks the part of "King of Beasts" and we shall not deprive him of his title.

The tiger, *Felis tigris*, is larger and longer than the lion. The ground color is tawny yellow above, marked on the face and back with darker stripes. The tiger ranges widely through Asia and the East Indies and is not confined to the tropical jungles of India but occurs as far north as southern Siberia. Tigers are much feared by the natives, not only because they destroy live stock but because they frequently attack man.

The leopard, *Felis pardus*, is much smaller than the tiger but is a dangerous pest of the smaller live stock and does not hesitate to attack man. It is rather generally distributed in Asia and Africa. There is much variation in color, but a typical leopard would have a body color of fawn spotted with darker.

The puma or mountain-lion, *Felis couguar,* is one of the largest of the American cats. It is nearly as large as a lioness and of the same general shape and tawny color. Different species of the mountain-lion formerly occurred throughout North America and southward into South America. It has been exterminated throughout most of its range except in the wilder and more remote regions. Tales of the ferocity of the "panther" have undoubtedly been greatly exaggerated but its large size makes it a dangerous foe if cornered or wounded.

The jaguar, *Felis hernandesii,* is another large American cat that formerly ranged northward into the southwestern states. It is tawny yellow, spotted with black somewhat like a leopard. The ocelots, *Felis pardalis*, are also spotted cats that occur from Texas southward into South America. They are of smaller size than the jaguar. The fur of these spotted cats is sometimes used.

The lynx, the bobcat or wildcat, *Lynx ruffus*, and the catamount are long-legged, short-tailed cats. They den commonly in hollow trees and on rocky ledges, where the kittens are born. They feed commonly on mice, hares and other small mammals but if hungry do not hesitate to attack larger mammals.

The aquatic carnivora include the walruses, the seals and the sea-lions. Both pairs of legs are developed as flippers and the tail is short. They spend most of the time in the water feeding on fish or mollusks.

The walruses, *Odobanus spp.*, are large mammals with the body nearly devoid of hair and with a pair of large tusks. They occur in the Arctic region. They are good swimmers but inferior to the seals. On the land their large size and weak limbs make them clumsy, awkward animals. These animals are strictly at home on the pack ice.

The seals are more slender, graceful animals than the walruses. They are more at home in the water than on the land and this group includes our most graceful swimming animals. They are divided into two families; the eared seals and hair seals. The eared seals including the famous fur seal and the sea-lions, as their name implies have external ears. The hair seals, *Family Phocidæ*, do not have external ears. This family includes the harbor seals, *Phoca vitulina;* the ribbon seals, *Phoca fasciata;* the hooded seals, *Cystophora cristata*, and the sea-elephants, *Mirounga anguatirostris*.

The fur seal, *Callorhinus alascanus*, breeds on the islands of the North Pacific, especially on the Pribilof Islands. They are polygamous and each mature male gathers a harem about him which may consist of several dozen females. The males that do not secure mates are known as bachelors and under present laws are the only ones that may be killed for fur. As soon as the young are able to shift for themselves at the end of the summer, the fur seals migrate southward to return to their breeding islands the following summer. Formerly fur seals were killed during these migrations. Under this method they were reduced to the point of extermination. Since pelagic sealing has been prohibited they have increased in numbers.

The two species of sea-lion, *Eumetopias jubata* and *Zalophus californicus* are found from California northward to Bering Strait. They live along the rocky coast and islands throughout this range. They are polygamous like the fur seal. The fur is not as highly valued as that of the fur seal.

The hair seals are primarily animals of the Arctic region which occasionally wander farther south. The color is variable in the different species but is generally yellowish-gray, more or less spotted with large or small dark spots, sometimes darker, almost uniform brown. The seals are intelligent animals that can be readily trained to do a variety of tricks, hence nearly every circus, whether large or small, has its troupe of trained seals. In contrast to the eared seals the hair seals are said to be monogamous although some species are gregarious and occur in herds of several thousands in favorable localities. The hair seals are much prized by the Eskimos not only for their blubber but also for their skins which are used for clothing and other purposes.

The sea-elephants are huge ungainly animals, the largest of the seals with the muzzle produced in a snout nearly as long as the head. One species is found along the coast of California and western Mexico, the other along the west coast of South America.

The hoofed mammals are divided into four orders, the even-toed mammals (Artiodactyla), the odd-toed mammals (Perissodactyla), the elephants (Proboscidea) and the sea-cows (Sirenia). Many of the even-toed mammals and the odd-toed mammals are familiar to everyone as common domestic animals. In the former order are the cow, camel, llama, alpaca, reindeer, sheep, goat and pig, and such well known wild animals as the hippopotamus, deer, elk, moose, giraffe, buffalo or bison, and gazelles. All these forms have the axis of the foot between the third and fourth toe and nearly all have well-developed horns.

The even-toed domestic animals will be discussed in another connection but a brief discussion of the more familiar wild animals will be given.

The hippopotamus, *Hippopotamus amphibius*, is a huge, ungainly, short-legged beast that is rather generally distributed in Africa. It lives an amphibious life, equally at home, on land or in water. While in the water it often leaves only the nostrils exposed. This beast feeds on the herbage along the river banks and also on the aquatic plants.

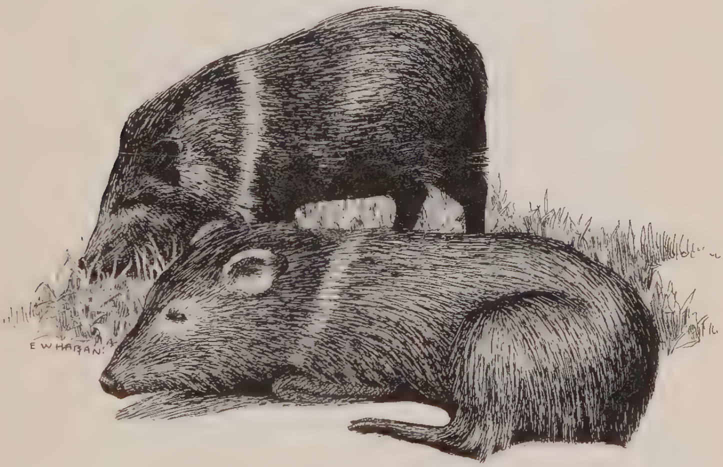


FIG. 9.—Collared peccaries. *Pecari angulatus*.

The *Family Suidæ* includes not only the domestic swine but many wild species found in Europe, Asia, the East Indian Islands and Africa. In general these wild hogs resemble the domestic species with the tusks better developed. In the Americas the swine-like peccaries, *Pecari angulatus* (Fig. 9), are found from Texas southward to South America. They resemble slender hogs with enormous heads and short tails.

The deer family, *Cervidæ*, is the largest family of even-toed mammals. The horns are solid outgrowths of the skull. They are usually present in the male only, but in some cases in the female also. The horns are shed each year and grown anew. The number of points are fairly accurate indications of the age of the animal, as generally a new point is acquired each year. Deer occur on all the continents except Australia and Africa.

The moose, *Alces americanus*, is the largest North American deer, averaging more than ½ ton in weight. It is confined to the northern United States and Canada. It may be distinguished not only by its large size but by its large antlers, which are broadly flattened.

The elk or Wapiti, *Cervus canadensis*, is next to the moose, the largest of our North American deer. It formerly ranged over most of North America but has been exterminated over most of its range save in the wilder parts of the Rocky Mountains. The horns are long and slender with long points.

The western mule deer, *Odocoileus hemionus*, and black-tail deer, *Odocoileus crooki*, have doubly branching antlers, thus differing from the white-tailed or Virginia deer. They also average slightly larger than the white-tailed.

The white-tailed deer, *Odocoileus spp.*, of various species and varieties is our most familiar deer as they have a wide range in North America and are still locally abundant wherever there are considerable areas that are still in a wild state. Even in such densely populated areas as the New England States they have thrived under protection and are now fairly abundant.

The caribous, *Rangifer spp.*, are northern animals ranging from the northern United States northward, the woodland species living in the forest areas and the barren ground species living north of the limit of tree growth. They are heavy-bodied deer with stout legs and heavy, irregular antlers, which are developed in both sexes.

The reindeer, *Rangifer tarandus*, is closely related to the caribous. It is a native of the Arctic regions of Europe and Asia and of Greenland. It has recently been introduced as a domestic animal into Canada and Alaska and may become an important meat animal and beast of burden as it is in Europe and Asia.

The pronghorn antelope, *Antilocapra americana*, formerly ranged over most of the western United States and northward into Canada. It is about the size of a small deer with peculiar short, flattened horns which are present in both sexes and which are shed each year.

The *Family Bovidæ* include not only the domestic sheep, goat and cow, but a number of wild forms closely related to these animals, such as the mountain sheep or bighorn, the Rocky Mountain goat, the musk-ox, the gnu and the bison. This family differs from the deer principally in the character of the horns, which are hollow, not solid, and which occur characteristically in both sexes, although there are many exceptions to this rule. The horns of the Bovidæ are not shed each year but are permanent.

The Rocky Mountain sheep, *Ovis canadensis,* or bighorn lives in the higher western mountains. The horns are greatly developed in the male and curved upward, backward and then downward and forward in a broad curve. These graceful animals are perfectly at home on rocky ledges and steep slopes that would hardly seem to offer a footing for so large an animal.

The Rocky Mountain goat, *Oreamnos montanus,* is more northern in its distribution than the bighorn, but it occupies the same kind of rocky ledges. It is dirty white in color with long, shaggy wool, evident beard and short, black horns.

The musk-ox, *Ovibus moschatus* (Fig. 10), lives in the barren grounds of North America beyond the timber line. It is a heavy-bodied animal with stout horns which curve downward and forward, and long, shaggy hair which is blackish-brown in color.

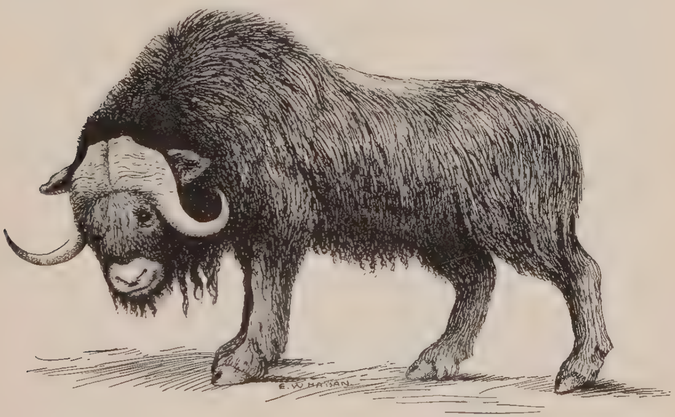


FIG. 10.—Musk-ox. *Ovibus moschatus.*

The antelopes occur in India and Africa. The species vary considerably in size. They have rather slender bodies and legs, a short tail and usually long horns which are nearly straight or slightly curved. In the oryx the horns are very long and annulated. The gazelles are slender, graceful animals, noted for their speed.

The bison, *Bison americanus* (Fig. 11), was formerly abundant in the great plains region but the advance of civilization has driven it out. The male is a powerfully built animal with heavy head, neck and forequarters, and frequently weighs upward of a ton.

The camels, *Camelus spp.*, both the dromedary or single-humped species, and the double-humped species or bactrian camel are well known beasts of burden, especially in desert regions to which they are well adapted.

The alpaca and the llama, *Lama huanacos*, occur in South America. They are smaller than the camel and are also used as beasts of burden.

The giraffes, *Giraffa spp.*, are the tallest of mammals, with long slender legs and a long neck. The general color is brown with paler reticulated markings. The giraffe lives in equatorial Africa.

In the odd-toed mammals the axis of the foot is through the third toe. In the best known forms such as the horse, the ass and the zebra the foot is reduced to one toe, the third. In the tapir the third toe is better developed than any of the other toes. The odd-toed mammals include in addition to the domesticated horse and ass, the zebra, the tapir and the rhinoceros.

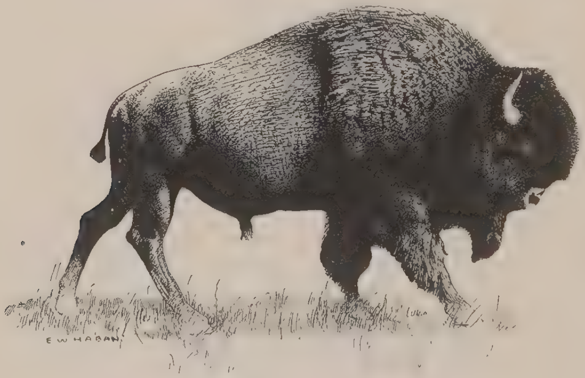


Fig. 11.—Buffalo. *Bison americanus.*

The zebras, *Equus spp.*, are confined to Africa. They are ass-like animals with a short mane, short tail and with the body conspicuously marked with black and white stripes. These stripes are differently arranged in the different species, and in the tall grass of their native habitat are said to camouflage the animals quite successfully.

The tapirs are somewhat pig-like, odd-toed mammals with four toes in front and three toes behind with the third toe always the largest. These animals are found in the Malay Peninsula, Borneo, Sumatra and a different species in Central and South America, *Tapirus terrestris.*

The different species of the rhinoceroses, *Rhinoceros spp.*, live in marshy situations in the warmer parts of Asia and Africa. They are huge, ungainly mammals with short, thick legs. The skin is very thick and almost devoid of hair. The nose bears one or two median, conical, sharp-pointed horns which are powerful weapons of offense and defense.

In the elephant, *Elephas spp.*, the head is prolonged into a long snout-like proboscis. All forms are remarkable for their large size, as they are the largest of present-day land mammals, and for the development of the tusks, modified from a pair of incisors in the upper jaw. There are two general types of elephants, the Asiatic with relatively small ears and the African with large ears. The Asiatic elephant is the more docile and has been extensively domesticated as a beast of burden.

The sea-cows or manatees, *Trichechus latirostris*, are whale-like aquatic animals living in fresh water streams. The general color is bluish-black and the skin is nearly devoid of hair. Our North American forms are found in Florida and the West Indies.

The primates include the lemurs, monkeys, apes and man. They are chiefly tropical in their distribution and chiefly arboreal in their habits, feeding mostly on fruits and nuts. The lemurs (Fig. 12) are typically small or medium-sized mammals with long bushy tails. They are found in Africa, Madagascar, India and the East Indian Islands.

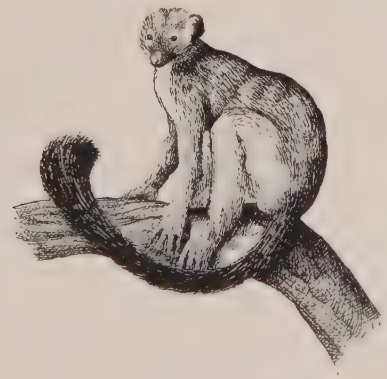


FIG. 12.—Lemur. *Lemur sp.*

The marmosets, *Family Hapalidæ*, are found in Central and South America. They are somewhat more monkey-like than the lemurs with round heads and more slender tails.

The New World monkeys have broad flat noses and usually elongate, prehensile tails. This group includes the common monkey of the hand-organ man. The long-tailed, long-armed spider monkeys of the Amazon region are strictly arboreal. The hand is without a thumb and the fingers are used like a hook. The squirrel monkeys are small-sized monkeys with elongate non-prehensile tails. The howler monkey has a long prehensile tail and a well-developed thumb. They make a hideous noise which is said to carry for miles. The Old World monkeys have narrow high-ridged noses. They include forms with both long and short tails.

The baboons, *Cynocephalus spp.*, inhabit central Africa. They are somewhat dog-like monkeys with short tails. The drill and the mandrill are baboon-like monkeys with short tails and peculiar grooved swellings on the face. The macaques are monkeys with long tails that inhabit Asia and the Philippines. They usually thrive well in captivity and are quite common in zoölogical parks.

The gibbons, *Hylobates spp.*, the orang-utan, *Simia satyrus;* the chimpanzee, *Anthropopithecus troglodytes*, and the gorilla, *Gorilla gorilla*, comprise the group of man-like apes. The gibbons are tailless apes with long arms. They are strictly arboreal and live in the Malay Peninsula and the East Indies.

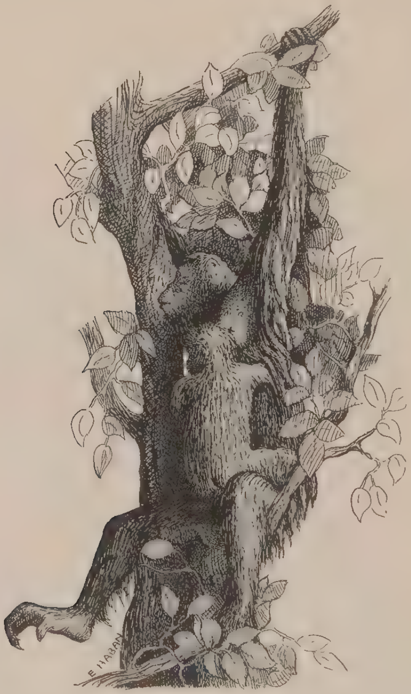


FIG. 13.—Orang-utan. *Simia satyrus.* With young.

The Orang-utan (Fig. 13) lives in the large East Indian Islands, Borneo and Sumatra. It is about 4 feet tall with an arm expanse of 7 feet. It builds a nest in trees and lives chiefly on fruit.

The chimpanzee lives in central Africa. It is slightly larger than the orang-utan, being about 5 feet tall. It is the ape that is most frequently seen in captivity and most of the individuals in the zoölogical parks seem to be docile and playful.

The gorilla is the largest of the apes. Its home is in the depths of the forests of the Congo. It feeds principally upon fruits and bark. The gorilla is generally credited with being a very ferocious animal, but these tales may have originated from the observations of wounded animals, and may not give a true picture of the animal. These animals are apparently difficult to maintain in captivity, as most attempts have ended in failure.

RELATION OF DOMESTIC ANIMALS TO MAN.

Beasts of Burden.—Man early in his civilization appreciated the importance of the domestication of certain wild animals as beasts of burden. The history of man's attempts in this direction has never been completely written and the origin of most domestic animals is lost in obscurity.

Horses.—Horses, *Equus spp.*, were first domesticated in Asia, although the wild ancestors of our domestic horses are not definitely known. The horse is well adapted for speed on dry land. Although more than fifty different breeds of horses are known, they may be roughly classified into three groups: *ponies* for pet purposes, *race horses* for speed and *draft horses* for beasts of burden. Horses are chiefly of value to man because of their great endurance, speed and teachability. Truly wild horses do not exist on the American continent. Although the horse originated on our western plains, the so-called wild horses are simply feral individuals that have escaped from domestication. These wild or Indian ponies are all descendants of horses brought to this country by the white man. Before the coming of the white man horses were unknown to the Indian.

Asses.—The asses, *Equus spp.*, are natives of Asia and Africa. They are less graceful than the horse; the head is proportionately larger, the ears longer, the mane and tail shorter and more scraggly. They are for the most part desert-loving forms; more resistant than the horse and capable of subsisting on less food and water.

The Mule.—The mule, *Equus spp.*, is the result of the cross between a mare and an ass. While not possessing the speed of the horse they are very surefooted and are valued in mountain climbing. They are also more resistant to a hot climate and are therefore extensively used as beasts of burden in the warmer parts of the world.

Elephants.—The Indian elephant is extensively used as a beast of burden in Asia. While not as teachable as the horse and its relatives, it can be taught to obey the ordinary commands. Its chief assets, however, are its enormous strength and the proboscis which it can use to handle certain types of material such as logs, lumber and pipe.

Camels.—Two kinds of camels, the bactrian or double-humped, *Camelus bactrianus,* and the dromedary or single-humped camel, *Camelus dromedarius,* are extensively used as beasts of burden on the deserts of Asia and Africa. They are admirably fitted for this purpose as they can travel for long distances without repeated stops for water, their feet do not sink deeply into soft sand and their nostrils can be closed against the blowing sand of a sand-storm. The ability of the camel to travel long distances without drinking is due to the fact that the rumen of the camel's stomach is supplied with a number of water cells. The water cells are flask-shaped diverticulæ of the rumen. The mouths of the diverticulæ are closed by sphincter muscles. These diverticulæ are filled with water when the animal drinks. This water is released from the water cells as it is needed.

Llamas.—In the higher parts of the Andes mountains there are a number of small, humpless camel-like mammals variously called llamas, alpaca, vicuna, etc. These animals are apparently the domestic races of certain camel-like wild animals of this region. Because they are very surefooted, they were formerly extensively used as beasts of burden in these mountainous regions.

Reindeer.—The reindeer has a circumpolar distribution. It has been domesticated chiefly in Lapland, Finland, Norway and Siberia. It is used not only as a sledge animal but also as a pack animal and as a saddle animal. Its resistance to cold and its ability to travel at a good speed over loose snow makes it a valuable beast of burden in these regions.

Oxen.—Oxen were formerly more extensively used as beasts of burden than they are today. They are animals of great strength, but slow and plodding. Their spreading hoofs are adapted to moving in swampy places where horses would mire down.

The Buffaloes.—The yak, *Bos grunniens,* is a buffalo-like animal of the higher plateaus of Tibet and is extensively domesticated and used as a beast of burden. The buffalo of India, *Bos indicus,* has also been domesticated and used as a beast of burden. It is a swamp-loving form and is extensively used in cultivating rice in parts of Asia.

Dogs.—The Eskimo dogs are used for pulling sledges in the Arctic region. They are swift, have great endurance and make excellent beasts of burden in a region that is very unfavorable for most domestic animals.

Meat Animals.—Animals have been extensively domesticated to furnish meat for man. The even-toed ungulates furnish the bulk of the world's supply of meat. Of the ungulates the hog, the cow, the sheep and the goat furnish the most of the world's supply of meat. It is estimated that more than 20,000,000 cattle and calves, more than 15,000,000 sheep, lambs and goats, and more than 80,000,000 swine are slaughtered each year in the United States. The leading cattle countries of the world are India, the United States, Argentina, Russia and Brazil. The principal sheep countries are the United States, Brazil and Germany. The principal swine countries are Australia, Russia, the United States, Argentina and South Africa.

In addition to these more familiar meat animals other ungulates are used extensively for food in various parts of the world. The llama and its relative, the alpaca in South America and the reindeer in Arctic countries. The reindeer has been introduced into Alaska recently. It is fast becoming an important meat animal in that region and is becoming an important export.

Very few of the rodents have been domesticated but the European rabbit is an important meat animal in many parts of the world and is being more and more extensively cultivated in this country for meat purposes.

Milk Animals.—The domestic ungulates in addition to furnishing meat for human consumption furnish milk. Milk with its products, butter and cheese, are important articles of diet in all parts of the world. The chief milk animal is the domestic cow. But the milk goat, the llama, the camel and the reindeer furnish milk and are extensively used for this purpose in various parts of the world.

Skins for Leather.—Man has long used the skin of various animals after proper tanning for such purposes as shoes, articles of clothing, harness, saddles, belts, and in the arts, especially in bookbinding. Leather is supplied chiefly from the hides of domestic animals slaughtered for meat purposes, although the hides of other domestic and wild animals are used for this purpose. Leather for various purposes must be durable, pliable and resistant to cold and dampness.

Wool.—The animal fiber wool is used extensively for weaving into cloth. The wool of the sheep is the most important animal fiber but the wool of the goat, alpaca, and camel are extensively used. Woolen cloth is durable and is especially valuable because it is resistant to cold and damp.

Pets.—From the hundreds of kinds of mammals that man has tried to tame and domesticate for pets, only two, the cat and the dog, have really become popular and of general distribution. Such forms as the rabbits, hares, squirrels, guinea-pigs, white rats, white mice, monkeys, skunks, bears, deer, lions, zebras, etc., have serious limitations either of size, disposition, attractiveness or ease of domestication which stands in the way of their becoming generally acceptable as pets. The story of the domestication of the cat and dog like the story of the domestication of most of the other common domesticated mammals is lost in antiquity. It is generally assumed that our common forms may be the result of fertile crosses between closely related species from Europe and Asia. And the great variety of kinds of dogs especially would seem to indicate a mixed ancestry.

Cat.—The history of the domestic cat dates back to early Egyptian times, and it was held in high esteem by those people. The cat is a favorite fireside companion not only because of its gentle disposition and playful traits but also because of its cleanliness. Its value as a destroyer of rats and mice will be discussed in another connection. Three types of cats are fairly common in this country; the common cat, the Angora or Persian cat and the manx cat. The common cat comes in an almost endless variety of colors but the more popular shades are black, white, maltese or blue, tabby and tortoise-shell. The Persian cat is noted for its long, silky fur and bushy tail. The manx cat is tailless or nearly so.

Dog.—Dogs, *Canis spp.*, have been pets of man for a long period. They rank high not only because of their intelligence and faithfulness but also because of the many ways in which they are beneficial to man. Nearly a hundred standard breeds of dogs are known today. These may be roughly classified as: *toy dogs* like the Pomeranians, Pekingese, poodles, spaniels and terriers; *show dogs* like the spitz, chow, dachshund, bulldogs and pugs; *hunting dogs* like the setters, retrievers, pointers, otterhound, deerhound, greyhound, wolfhound, great dane and foxhound; *shepherd dogs* like the collies, shepherd and sheep dogs (German Police); *sledge dogs* like the Eskimo dogs; and *racing dogs* like the whippets.

Minor Uses.—Domestic animals also furnish a number of produtcs that may be called by-products, which are of considerable importance. The hair removed from hides in tanning is used for padding in upholstered furniture and similar purposes. It is also used for reënforcing in plastering for houses. Glue and gelatin, which is used as a food, are manufactured from bones, skin, horns and hoofs of animals. Bone-meal used as a fertilizer, and tankage used as a source of proteins in animal feeds are from the same sources.

WILD ANIMALS IN RELATION TO MAN.

Wild Animals as Pests.—Rats and mice as destroyers of stored products have already been discussed. Many other wild animals are generally or occasionally troublesome to man or his domestic animals or his crops and must under such circumstances be classed as pests. It must be remembered however, that many animals which are innocuous or even beneficial under ordinary conditions may become important pests in times of scarcity of their ordinary food, or during periods of exceptional local abundance, or at times when the usual balance of Nature is disturbed. Man ought to keep these factors in mind and not condemn these exceptional culprits without due consideration of the after-effects. Thus, foxes may take an occasional hen, if hens are allowed to roost in exposed places instead of being sheltered in a properly constructed house, but the wholesale destruction of foxes would perhaps permit field mice and other rodents to increase to such an extent that they would destroy grain on a given farm many times in excess of the value of all the hens roosting in trees on that farm. The balance of Nature involves many factors and is easily disturbed, for example, by the clearing of new land, or by planting large areas in a single crop. Any disturbance of this kind may cause some particular mammal to become a pest. Only brief mention, therefore, can be made of some of the more important of these pests.

Moles are frequently destructive to lawns and gardens by running their tunnels through the sod, thus killing the grass or by running them down a row of vegetables. Various traps have been devised for the destruction of moles and poisons of various kinds have been recommended. These remedies are successful only if they are applied to the main runways of the mole and not to side runways, which are seldom used. Fumigation with carbon bisulphide and calcium cyanide may prove successful if used in a heavy wet soil where there is little leakage. Watching for the moles as they construct new tunnels early in the morning and destroying the moles is time-consuming but effective.

Many of the rodents such as mice, rats, squirrels and muskrats, which normally live on nuts, acorns, wild seeds or other plants, are occasionally destructive to grains or other crops. Field mice, rats and rabbits are occasionally destructive to orchards, especially to young trees, by gnawing the tender bark just at the surface of the ground, often girdling trees in this manner. Appropriate poisoned bait is about the only successful remedy for the control of all these pests, although traps and dogs and guns may be used against the larger forms such as the rabbits and the muskrats.

In many parts of the country the burrowing rodents are destructive to grains and grasses. These include the ground squirrels, the pocket-gophers, the prairie dogs and the woodchucks. The larger forms such as the woodchuck may be killed by fumigation, either with carbon bisulphide, calcium cyanide or carbon monoxide from the exhaust of an automobile, using a hose to pipe it to their burrows. The smaller forms may be successfully poisoned by the use of an appropriate bait.

Many of the larger carnivora are destructive to domestic animals, especially to the young. Wolves, foxes and coyotes take an annual toll of many animals. As a general thing hunting, trapping and poison baits are resorted to for the control of these pests. The smaller carnivora, such as the weasels and the mink, are frequently destructive to domestic poultry. As these animals prefer live prey it is rather difficult to trap them and as they are small they readily gain entrance to poultry houses. About the only successful remedy is to watch for and destroy them.

Animals as Destroyers of Pests.—Many of the carnivora, especially those belonging to the mink family, the dog family and the cat family, are important factors in the control of pests, especially the rats and mice. The cat and the ferret have been bred for this purpose and certain animals, such as the fox and coyote, unless otherwise destructive to domestic animals, should be protected for this purpose.

The mongoose, *Herpestes ichneumon*, has been introduced into the West Indies as a destroyer of poisonous snakes. It soon became abundant however, and turned its attention to domestic animals, thus becoming a pest itself.

Wild Animals as Carriers of Diseases.—Many species of wild animals act as carriers of diseases of man and his domestic animals. Thus the rat, ground squirrels and other rodents which harbor the rat flea may carry the germs which cause bubonic plague. In the Rocky Mountain region rodents of various kinds carry the dread Rocky Mountain spotted fever. This disease may be transferred from rodent to man by the bite of the spotted fever tick. In Africa the antelopes carry the germs of sleeping sickness which may be transferred from wild animal to man by the tse-tse fly. As will be pointed out in the chapter on the parasitic worms (see Chapters XII and XIII), many animals harbor or act as secondary hosts for these parasites of man and his domestic animals.

Wild Animals for Food and Sport.—Among primitive peoples, wild animals of various kinds are of prime importance for food but as a country becomes more and more settled wild animals lose their importance as a source of food and become of primary importance for sport. Unfortunately it is difficult for any people to realize the importance of game animals until they have practically become extinct. This country has witnessed the wanton destruction of one big game species after another. The buffalo, the elk, the deer, the bear, the pronghorn, and many others have been completely destroyed over large areas and are now to be found only in remote or isolated districts. With proper protection, however, all these species might still become abundant in many parts of the country, thus furnishing sport to many hunters and a source of revenue to regions of the country of little value for agriculture. Public sentiment is being developed in this connection and it is hoped that many smaller game animals can be saved the fate of their larger relatives.

The food and game animals fall principally in the Rodentia, and the Ungulata. The Rodentia furnish such common forms as the squirrels and the rabbits, and the Ungulata furnish the deer, the elk, the moose, the antelope, the bighorn and others.

Wild Animals for Skins and Furs.—Wild animals furnish skins for clothing for primitive people and furs for ornamentation of the more civilized peoples of the world. The demands for furs at present time far exceeds the supply and the world is being scoured for fur-bearing animals, and animal after animal finds itself led to the slaughter by the passing whim of fashion. The beaver, muskrat, seal, fox, skunk, ermine, chinchilla and many other species have walked the gang-plank to practical extermination and still the demand goes on. A tabulation of the latest figures available from the big London and New York markets will give a better notion of the extent of the fur trade than anything else that might be said. Figures are given in round numbers only and similar species are lumped together.

Table of the principal kinds of skins sold on the New York and London markets for 1920:

Kind.	Approximate number of skins.
Mole	975,000
Rabbits	850,000
Skunk	835,000
Muskrat	625,000
Opossum	750,000
Squirrel	525,000
Foxes	355,000
Ermine	250,000
Wallaby	190,000
Mink	150,000
Wolf	80,000
Civet cat	65,000
Raccoon	55,000
Minor species to make a total	5,685,000

Many of the kinds in this list can be called furs only by using this term in its loosest sense. How near the point of extinction many real fur bearers are may be gathered from the following table from the same source:

Kind.	Number of skins.
Beaver	11,600
Fur seal	8,900
Otter	5,600
Russian sable	3,200
Chinchilla	2,900

Prices of raw furs may be surmised when it is recalled that it may take 100 chinchilla skins to make a single wrap which may sell for $50,000, or 125 mink for a wrap worth $5000, 300 ermine in a wrap worth $3000. The table (P. 50) of high prices of skins will indicate what the fur trade considers the real furs at the present time.

TABLE OF PRICES PAID FOR SKINS IN 1920. THE HIGHEST PRICES ARE GIVEN IN EACH CASE.

Kind.	Highest prices.
Silver fox	$1225.00
Fisher	345.00
Cross fox	280.00
Marten	201.00
Beaver	106.00
Otter	105.00
Mink	75.00
White fox	70.00
Lynx	62.00
Red fox	51.00
Black bear	45.00
Wolf	45.00
Skunk	10.00
Muskrat	7.50

Substitution of cheaper furs for more expensive furs has become a fine art. Cheaper furs are bleached, plucked, dyed, blended, clipped or stenciled until only an expert can tell the real from the imitation. When rabbit skins bleached, dyed and stenciled parade our streets as leopard; unhaired, bleached or otherwise treated and sold as sable, seal, ermine or chinchilla; when prairie dog and woodchuck are blended and dyed to be sold as mink; when muskrat may be variously treated and sold as mink, seal or mole, it behooves the buyer of furs to find a reliable dealer.

Fur Farming.—To meet the growing demand for furs various attempts have been made at so-called fur farming. Many of these attempts are little more than efforts to trap only a limited number of animals in a given area or to protect the young, especially from the natural enemies. Other attempts at fur farming have gone farther and a real effort has been made to raise a wild species under controlled conditions approaching domestication. Some species like the foxes respond fairly well to these conditions while others, like the skunk, have not responded so well. Any type of fur farming is at best a hazardous undertaking, as the animals may refuse to breed in confinement, or they may die of diseases. Anyone contemplating engaging in fur farming should determine the species suited to his region and conditions and then study the general habits, breeding habits, food, enemies and diseases before engaging in the business. Also it must be remembered that fur farming is but a specialized branch of stock farming and that fur bearers, to maintain themselves under confinement, may require much more attention than domestic animals require to thrive. If undertaken in a haphazard manner fur farming is doomed to failure, but if all the factors of housing, breeding, care of the young, sanitation and feeding are carefully considered, fur farming can be made a profitable form of agriculture, especially in regions not suited to other types of farming.

At the present time silver fox farming is being successfully conducted in Canada. Blue fox farming in Alaska, and mink farms are profitable ventures in many parts of the United States. Muskrats are raised principally in the swampy areas from New Jersey to Maryland. The chief item is to keep out natural enemies as much as possible and to provide an abundance of food by growing it on the marshes. Rabbits for both meat and skins are extensively grown in many parts of the country, but rabbit farming has reached its greatest development in Southern California.

Whalebone and Oil.—From the middle of the eighteenth to the middle of the nineteenth century the whaling industry was one of the great industries of the world; since that time the industry has fallen off to practically nothing. This is due not only to the use of cheaper substitutes for whale oil and whalebone, but also to the fact that the number of whales have decreased to the point where it is no longer profitable to whale for them. Beddard says that whereas in 1861 eight vessels took 121 whales, the same number of vessels in 1897 took only 9 whales. Whalebone was formerly extensively used in the manufacture of many articles where its flexibility, lightness and toughness were important factors. Whale oil was formerly used for the lubrication of machines of all kinds. Its chief importance, however, is in the lubrication of delicate machines like watches and clocks, where an oil of the finest quality and the greatest durability is required.

CHAPTER II.

THE BIRDS IN RELATION TO MAN.

(Class Aves.)

Characters
Classification
Chief Value to Man
    Food and sport
    Eggs and other products
    Birds as friends of man
    Birds as enemies of man

Bird Migration
Nesting Habits
Songs

CHARACTERS.

The outstanding characters of the birds are these: (1) The body is covered with feathers. (2) The mouth is without teeth, the jaws being modified into a horny beak. (3) The forelimbs are modified into wings. (4) The pelvic skeleton is firmly anchored to the vertebral column to support the bird on the hind limbs. (5) The digestive system is variously modified according to the food eaten. There may be a crop for the storage of the food and the stomach is then modified into a muscular gizzard for the grinding of food. (Fig. 14.)

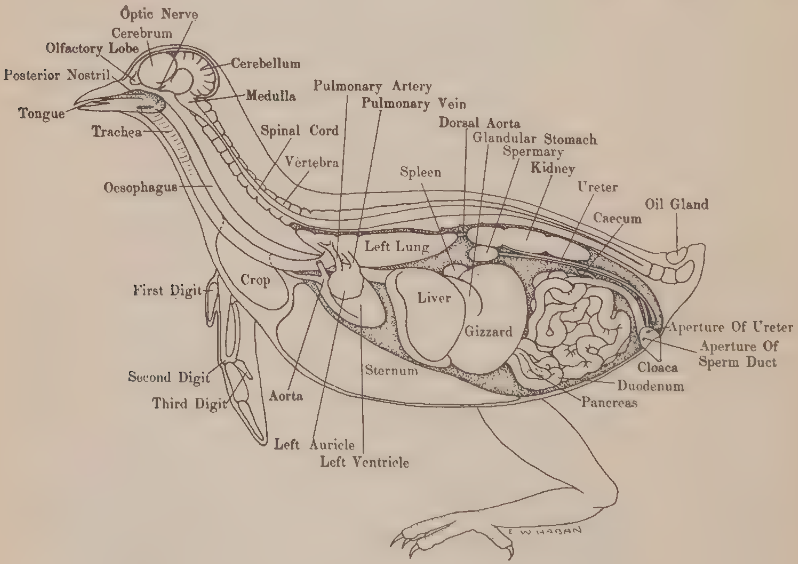

Optic Nerve
Cerebrum
Olfactory Lobe
Cerebellum
Posterior Nostril
Medulla
Pulmonary Artery
Pulmonary Vein
Tongue
Trachea
Spinal Cord
Dorsal Aorta
Glandular Stomach
Spermary
Kidney
Vertebra
Spleen
Ureter
Oesophagus
Oil Gland
Caecum
Left Lung
Crop
First Digit
Liver
Gizzard
Aperture Of Ureter
Aperture Of Sperm Duct
Cloaca
Sternum
Duodenum
Second Digit
Third Digit
Aorta
Pancreas
Left Auricle
Left Ventricle
E W HABAN

Fig. 14.—Diagram showing the internal structure of a bird.

CLASSIFICATION.

The more important North American birds together with some of the larger or more conspicuous birds from other parts of the world may be classified as follows:

- RUNNING BIRDS.
  - Order Struthioniformes—The ostriches.
  - Order Rheiformes—The rheas.
  - Order Casuariiformes—The emeus, the cassowaries.
- FLYING BIRDS.
  - Diver-like birds.
    - Order Colymbiformes.
      - Family Podicipidæ—Grebes.
      - Family Colymbidæ—Loons.
    - Order Sphenisciformes—Penguins.
    - Order Procellariiformes.
      - Family Diomedeidæ—Albatrosses.
      - Family Procellariidæ—Petrels.
  - Stork-like birds.
    - Order Ciconiiformes.—Wading birds.
      - Family Pelecanidæ—Pelicans.
      - Family Sulidæ—Gannets.
      - Family Phalacrocoracidæ—Cormorants.
      - Family Anhingidæ—Snake birds.
      - Family Fregatidæ—Man-of-war birds.
      - Family Ardeidæ—Herons.
      - Family Ibididæ—Ibises.
      - Family Ciconiidæ—Storks.
      - Family Phœnicopteridæ—Flamingos.
      - Family Plataleidæ—Spoonbills.
    - Order Anseriformes—Swimming birds.
      - Family Anatidæ—Ducks, geese, swans.
    - Order Falconiformes—Birds of prey.
      - Family Cathartidæ—Vultures.
      - Family Falconidæ—Falcons, eagles, hawks.
      - Family Pandionidæ—Osprey.
  - Fowl-like birds.
    - Order Galliformes—Scratchers.
      - Family Phasianidæ—Pheasants.
    - Order Gruiformes.
      - Family Rallidæ—Rails.
      - Family Gruidæ—Cranes.
    - Order Charadriiformes—Plovers.
      - Family Alcidæ—Auks.
      - Family Laridæ—Gulls.
      - Family Charadriidæ—Snipes.
      - Family Columbidæ—Doves.

PERCHING BIRDS.
- Order Cuculiformes.
  - Family Cuculidæ—Cuckoos.
  - Family Psittacidea—Parrots.
- Order Coraciiformes.
  - Family Alcedinidæ—Kingfisher.
  - Family Strigidæ—Owls.
  - Family Caprimulgidæ—Night hawks.
  - Family Trochilidæ—Humming-birds.
  - Family Micropodidæ—Swifts.
  - Family Picidæ—Woodpeckers.
- Order Passeriformes—Song birds.
  - Family Tyrannidæ—Flycatchers.
  - Family Alaudidæ—Larks.
  - Family Corvidæ—Crows and jays.
  - Family Sturnidæ—Starlings.
  - Family Icteridæ—Blackbirds.
  - Family Fringillidæ—Finches.
  - Family Tanagridæ—Tanagers.
  - Family Hirundinidæ—Swallows.
  - Family Bombycillidæ—Waxwing.
  - Family Laniidæ—Shrikes.
  - Family Vireonidæ—Vireos.
  - Family Mniotiltidæ—Warblers.
  - Family Troglodytidæ—Wrens.
  - Family Mimidæ—Mocking-birds.
  - Family Certhiidæ—Creepers.
  - Family Sittidæ—Nuthatches.
  - Family Paridæ—Titmice.
  - Family Sylviidæ—Kinglets.
  - Family Turdidæ—Thrushes.

The running birds include our largest existing birds, the ostriches, the rheas and the emeus. The ostrich, *Struthio camelus* (Fig. 15), is a native of the desert regions of Northern and Southern Africa. These birds are powerfully built with small heads, long necks and long legs with only two toes. The plumes have been used for ornaments since ancient times.

The rheas, *Rhea spp.*, are the ostriches of South America. They have a general resemblance to an ostrich but have three instead of two toes.

The cassowaries, *Casuarius spp.*, are the ostriches of New Guinea. They are smaller than the ostriches with shorter necks and legs. The emeus, *Dromæus spp.*, are larger than the cassowaries, nearly as large as an ostrich with a much shorter neck. They live in Australia.

The grebes, *Family Colymbidæ,* are small or medium-sized diving birds with lobed feet. Six species are found in North America. The best known species is the pied-billed grebe or hell-diver. It occurs over most of North and South America. It is an expert diver and has the reputation of diving at the flash of the gun.

The loons, *Gavia spp.*, are larger than the grebes. Our common northern loon has the back and wings checked black and white. It is also an expert diver, really swimming under water. Its call is a weird laugh and is well known to people living in its breeding range.

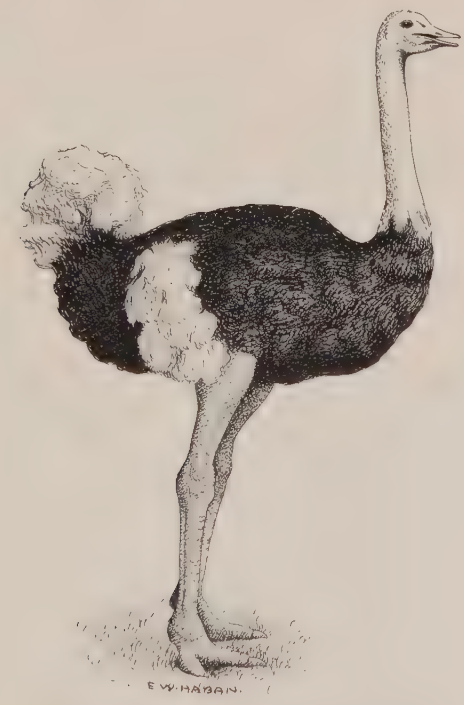


Fig. 15.—African ostrich. *Struthio camelus.*

Loons nest from the northern United States to the Arctic Circle. They migrate southward to winter chiefly in the South Atlantic and Gulf States.

The penguins, *Aptenodytes spp.*, are flightless diving birds that inhabit the Southern Hemisphere. The emperor penguin lives on the ice in the Antarctic region. It is one of the largest of the penguins. The feathers are almost scale-like, especially on the wings, which are reduced and flipper-like. The wings are not suitable for flight but are used for swimming under water. This bird is a most expert diver and can swallow fish under the water.

The albatrosses, *Diomedea spp.*, are birds of the open sea. They are of large size with a wing expanse of a dozen feet or so. They have great endurance and will follow ships by the hour or day, sailing on almost motionless wings as they skim over the waves.

The petrels, *Oceanites spp.*, are known as Mother Carey's chickens to the sailors. They are pelagic birds of small size and occur at mid-ocean. These birds nest in burrows or crevices of rocks on small islands in various parts of the world. As they skim over the surface of the water they seem to be literally walking on the water, hence the name petrels (Little Peters). The wonder is that so small a creature about the size of a small thrush can live so far from land and survive heavy storms at sea.

The cormorants, *Phalacrocorax spp.*, are world-wide in distribution. Our common North American species are blackish-brown in color with long heavy necks. The feet are fully webbed and the bill is long and hooked at the tip. Cormorants are gregarious and live in large colonies near the coast or near inland lakes or ponds. They nest on rocky ledges or in trees near the water and are excellent swimmers and divers, catching fish under water.

The pelicans, *Pelecanus spp.*, are found principally in the warmer parts of the world, chiefly along the sea coast, sometimes inland. Pelicans are large, heavy bodied, goose-like birds with fully webbed feet and an elongate bill sharply recurved at the tip. The lower bill is provided with a pouch which is used like a net to scoop up several gallons of water. The water is strained from the mouth and any fish that have been captured are swallowed.

There is but a single species of snake bird, *Anhinga anhinga*, in North America and South America. It breeds as far north as North Carolina and from there to tropical America. This is a small family of birds for in addition to the American species there are but three other species, one each in Africa, Asia and Australia. All of them are slender birds with long, slender snake-like necks and fully webbed feet. They live on the borders of ponds surrounded by woods.

Only two species of man-o'war birds, *Fregata spp.*, are known. They inhabit the tropical oceans of the world and are among the most graceful fliers in the animal kingdom. The wings are long and pointed with an expanse of more than 7 feet. The tail is long and forked, the feet are webbed and the bill is strongly hooked. They feed on fish which are captured on the wing if the fish come too near the surface or leap into the air. The man-o'war bird also has the habit of pursuing and robbing other smaller birds of their prey.

The *Family Ardeidæ* includes the bitterns and herons. Structurally these birds are similar but their habits are quite different. They are medium to large-sized birds with long necks, bills and legs. The toes are short and often slightly webbed. The bitterns (Fig. 16) live generally in marshes and build their nests on or near the ground. They are secretive and prefer to remain concealed by the grasses or rushes of their favored haunts.

The herons frequent open water, where they secure their food, which consists chiefly of frogs, tadpoles, fish, reptiles and crustaceans. They build their nests in trees or bushes, often some distance from the water and frequently in great colonies.

Our two most familiar herons in eastern North America are the great blue heron or crane, *Ardea herodias*, and the green heron, poke or fly-up-the-creek. The great blue heron is a large bird of majestic mien as it stands quietly knee deep in the water at the edge of a pond or lake waiting for some unfortunate frog or tadpole to come within striking distance. Too often these birds are the luckless targets of so-called sportsmen who kill for the love of killing. These birds are not fit for human food and it requires about as much marksmanship to hit a motionless crane as to hit a post or tree.

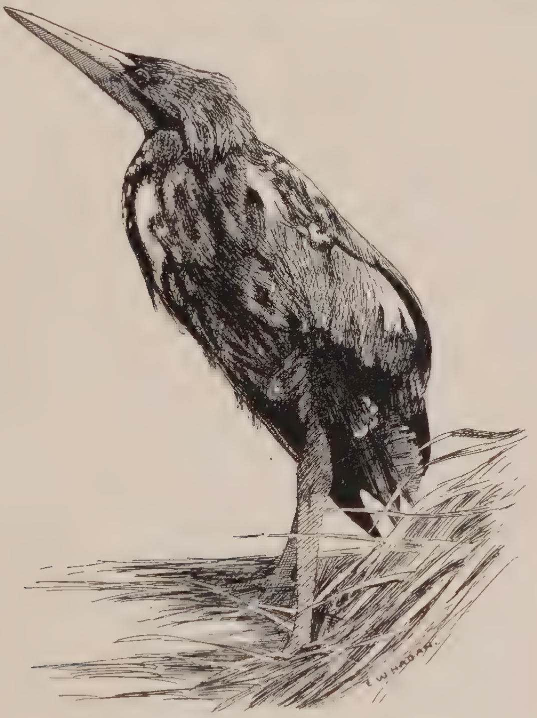


FIG. 16.—American bittern. *Botaurus lentiginosus.*

The green heron, *Butorides virescens*, is a medium-sized bird. It frequents streams and ponds where it feeds on small frogs, reptiles, crayfish, etc. It has a long list of common names but is familiar to all country boys, as it seems to be fairly common throughout its summer range. It spends the winter from the southern part of Florida southward.

The southern United States has two species of egrets, *Herodias egretta* and *Egretta candidissima*, which are white herons with the head provided with long plumes called aigrettes, which were formerly much prized by the millinery trade. After being brought almost to the point of extinction these birds received protection and seem to be holding their own.

The southern United States also has a number of medium-sized dark slaty-blue herons, which are pure white when young. These young white herons are frequently confused with the egrets.

The storks are heavy-bodied birds with long legs, moderate necks and long, powerful, conical bills. The species of this family are found principally in Europe, Asia and Africa. One species, the wood ibis, *Mycteria americana*, occurs in tropical and subtropical America, breeding in the Gulf States and wandering occasionally farther north. The head and neck are bare, the feathers of the body are white and the tips of the wings and tail are greenish-black. The nest is a platform of sticks in a tree. The European stork, *Ciconia alba*, is well known, as it builds its nests, a rough platform of sticks, on the roofs or on broad chimneys or on platforms constructed for this purpose. As the presence of these birds is supposed to bring good luck to the household, they are never disturbed.

The ibises, *Family Ibididæ*, are also stork-like birds that live in the warmer parts of the world. The neck is not very long for a stork-like bird, but the bill is long, cylindric and slightly curved. Three species occur regularly as far north as the United States. The white ibis, *Guara alba*, is white but the other two species are deep chestnut-brown in color.

The flamingoes are chiefly birds of the tropics. Only one species, *Phœnicopterus ruber*, reaches our Gulf States. It is a tall stork-like bird with long neck and long legs of a beautiful rosy-red color. The bill is large and of peculiar shape, the lower bill forming a deep spoon or shovel-like box into which the upper bill fits like a lid. The beak is bent in the middle. Its bill is used to sift the soft mud on the tidal flats and remove the small animals on which the flamingo feeds. The nests of the flamingo are built of mud on the mud flats. They are elevated from 1 to 1½ feet above the mud and hollowed out on top. A pair of eggs is laid in this hollow.

The spoonbills receive their names from the spoon-shaped bills which are flattened and broadened at the tip. They are birds of the tropical and semi-tropical parts of the world. One species, *Ajaia ajaia*, wanders north to our Gulf States. It is a large bird of stork-like characters and pink color. These striking birds have been much persecuted and are becoming rare. They are gregareous, feeding in flocks in shallow water and nesting in colonies, building rough platforms in trees.

The *Family Anatidæ* includes the fish ducks, the river ducks, the sea ducks, the geese and swans. Typically the bill is rather broad and flattened, the toes are fully webbed and the neck is long and slender. All are excellent swimmers and divers, thoroughly at home in the water. Most of the species are strong, swift fliers and migrate for long distances. With the exception of the fish ducks they are considered among our most valuable food and game birds and are, therefore, generally well known.

The fish ducks have the edges of the bill narrower than in the other ducks and serrate for capturing and holding fish. Our fish ducks breed generally from the northern United States northward, migrating for the winter to the southern United States. The commoner species usually nest in a hollow tree near the water.

The river or pond ducks have broad flat bills for probing the bottoms in shallow water where they pick up insects, shell-fish and the seeds and roots of plants. While feeding in this manner they stand on their heads. Our species are small or medium swift-flying ducks, generally much prized by the sportsman.

The mallard or green-headed duck, *Anas platyrhynchos*, has the head and neck glossy green, with a white ring around the neck, breast bright chestnut and the speculum of the wings bright purple. The female is obscure blackish-brown and is usually not distinguished from the nearly related black duck. The mallard has been domesticated and is one of the best known ducks. The teals are small river ducks noted for their excellent flesh and their swift flight. The male wood duck is the most beautiful North American duck with bright metallic coloring, bright chestnut breast and white belly. It was formerly abundant over North American but has been hunted almost to the point of extinction. The wood duck, *Aix sponsa,* nests in hollow trees along streams or around ponds throughout North America, but the other species all nest in grassy marshes on the ground, generally from the northern United States northward.

The bay or sea ducks live principally on the larger bodies of water such as large lakes, bays and the open sea. This group comprises the majority of our North American species. They generally feed by diving in deep water, not in shallow water, as the pond ducks. The most famous duck of this group is the canvas-back, prized by epicureans for its delicate-flavored flesh. These ducks usually breed in the northern part of North America, migrating southward to the South Atlantic and Gulf States to spend the winter.

The geese average larger than the ducks. They feed on aquatic or other plants and are often found on land pasturing on grass or other plants. The Canada goose, *Branta canadensis,* is the largest North American species. It nests in the Northern States and Canada and migrates in V-shaped flocks to the Southern States for the winter.

The swans, *Oler spp.,* are large white birds with the neck as long as the body. They feed on water plants and small aquatic animals found in shallow water. These birds nest in the northern United States, migrating southward in V-shaped flocks. They congregate in large flocks in favorable waters and are said to resemble a glistening ice-floe when viewed at a distance.

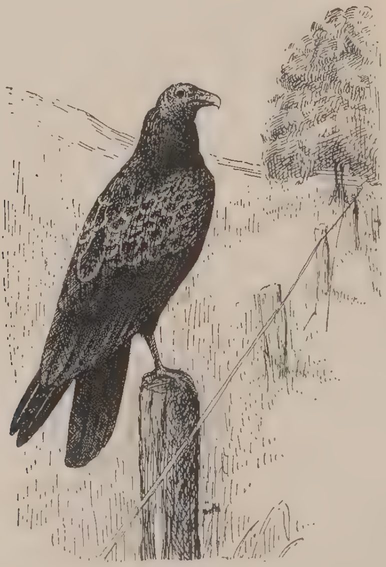


Fig. 17.—Turkey buzzard. *Cathartes aura septentrionalis.* (After Snyder.)

The *Family Cathartidæ* includes the American vultures or buzzards. These are large birds with prominent hooked beaks and strong talons. The nostrils are not separated by the nasal partition and the head is bare. These birds feed on carrion but in spite of this disgusting habit they are interesting birds. Their flight is characteristically soaring and they can apparently soar for hours at a time without beating the wings to any extent. The turkey buzzard, *Cathartes aura* (Fig. 17), and the black buzzard, *Catharista urubu,* occur commonly in the southern United States, ranging as far north as the northern tier of States. In the turkey buzzard the bare skin on the head and neck is bright red while in the black buzzard it is black. Otherwise the buzzards are quite similar in appearance and also in habits. The nest is usually placed beside a log or stump, or on a rocky ledge. The California vulture, *Pseudogryphus californianus*, and the condor are very large vultures, the former living in the higher mountains of southern and lower California. The condor, *Sarcorhamphus gryphus*, which lives in the higher parts of the Andes mountains has a wing spread of 12 feet.

The *Family Falconidæ* includes the kites, the hawks and the eagles. They are diurnal birds of prey with strong hooked beaks adapted for tearing flesh and strong talons for catching prey. Most of our species are masters of the air, capable of swift flight or of remarkable feats in soaring for long periods without evident motion of the wings. Most of our species are either beneficial by destroying insects and rodents or neutral. Some are decidedly injurious to wild birds or domestic fowls. The kites are slender hawks famous for their graceful flight. The swallow-tailed kite, *Elaonides forficatus*, has a long forked tail and resembles a large swallow when on the wing, The hawks most destructive to young poultry are the medium-sized sharp-shinned hawk, *Accipiter velox* (Fig. 18), and the Cooper's hawk, *Accipiter cooperi*. They are bluish-gray above and swift fliers and are often called blue darters.

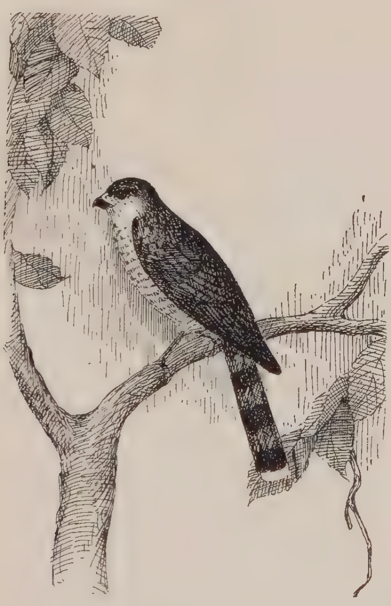


FIG. 18.—Cooper's hawk. *Accipiter cooperi.* (After Snyder.)

The larger hawks, like the red-tailed, *Buteo borealis*, and red-shouldered hawk, *Buteo lineatus*, are often called hen-hawks. They are brownish above and are noted for their ability to soar.

The eagles include two widespread American species, the more northern golden eagle, *Aquila chrysætos,* which lives in the Northern States and Canada, and the bald eagle, *Heliæetus leucocephalus,* which occupies the whole of North America south to Mexico. Eagles are large birds of prey. They have been accused of all the crimes on the calendar, including carrying away babies. The golden eagle feeds principally on small mammals, such as rabbits, and the bald eagle feeds principally on fish. They are not usually destructive to domestic animals or birds, as they are shy and shun human habitations. The mature bald eagle has a white head and neck and a white tail with the rest of the plumage brownish-black. It may be readily distinguished from the golden eagle. The immature bald eagles are brownish-black in color without the white head and tail. Therefore, they have a general resemblance to the golden eagle. The two species may be distinguished by examining the legs, which are feathered to the toes in the golden eagle and bare in the bald eagle.

The *Family Pandionidæ* includes a single species, the osprey, *Pandion haliæetus,* which is nearly world-wide in distribution. It bears a general resemblance to a large hawk, with its hooked beak and strong claws, and is quite commonly called a fish-hawk. It feeds on fish, which it captures by hovering and then suddenly darting down and grasping the fish in its sharp claws. The captured fish is carried away to some convenient place to be devoured. The osprey builds a large platform of sticks in a tree which it uses for a nest.

The *Family Phasianidæ* includes the quail or bob-white, the partridges, the grouse, the ptarmigans, the prairie-hen, the heath hen, the pheasants, the turkey and the domestic fowl. This group includes some of the most famous game birds and the most important domestic birds for meat and eggs. These birds are scratchers, living on the ground and feeding on seeds, chiefly. They are short, stout-bodied birds with short, hard bills, short wings and the tail usually short, sometimes very long.

The bob-white, *Colinus virginianus* (Fig. 19), quail or partridge is too well known to need description. It is widely distributed in the Eastern States westward to the Rocky Mountains. It is a famous game bird, but is valuable as an insect destroyer and should not be hunted to the point of extinction.

The partridges are found in the far west and the southwest. They differ from our eastern species in color and in having a tuft of feathers on top of the head.

The ptarmigan, *Lagopus lagopus,* is an Arctic bird which is brownish in the summer plumage and pure white in winter.

The grouses, *Subfamily Tetraonidæ,* comprise a group of large pheasants. They inhabit woodlands and are famous game birds. They have been hunted almost to the point of extinction, but with proper protection they might be saved from extinction. The ruffed grouse, *Bonasa umbellus*, is famous for the drumming noise that he makes during the breeding season.

The prairie-hen, *Tympanuchus americanus*, is a famous game bird of the Great Prairies region. It has been extensively hunted and is not as common as formerly. Its eastern relative, the heath hen, *T. cupido*, was formerly common in the woods of the North Atlantic States. It was hunted so extensively and so persistently however, that it became extinct throughout its range save on Martha's Vineyard Island, about the middle of the last century. Since that time it has just barely held its own on this island, due to insufficient protection, and is now on the verge of extinction. Another example of the insatiable appetite of the hunter, who for his own pleasure wantonly destroys what he cannot replace.

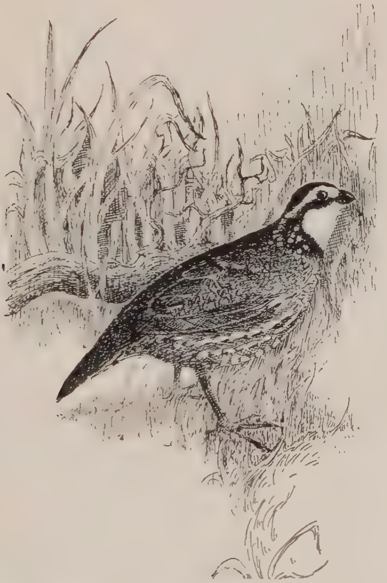


FIG. 19.—Bob-white. *Colinus virginianus*. (After Snyder.)

The pheasants are large birds natives of Asia. The males are often ornamented with bright-colored plumage and long tails. Some species of pheasants, notably the silver and golden pheasants, do fairly well under semi-domestication on game reserves and as they make excellent shooting they are being more and more cultivated.

The peacock, *Pavo cristatus*, is the handsomest of the pheasant tribe. This bird is a native of India and has been introduced into this country where it lives in semi-domestication.

The turkey, *Meleagris gallopavo,* is a native of North America, ranging formerly from southern Canada to Central America. Wild turkeys are still our noblest game birds. They still hold their own in the wilder and more remote parts of the United States, although many of the wild turkeys that are shot each year are simply domesticated birds that have strayed too far from home. The wild turkey was domesticated by the early settlers and domestic birds were sent to Europe in the early part of the sixteenth century.

The domestic fowl, *Gallus bankiva,* is believed to be descended from the jungle fowl of India and the East Indies. Many different breeds have been developed by selection and the domestic fowl is the most important bird in the world, both from the standpoint of eggs and meat.

The *Family Rallidæ* includes the rails, gallinules and coots. The rails are small or medium-size birds living in salt or fresh water marshes or wet meadows. The different species are generally brownish in color variously marked with dark brown or black. These little birds are much prized for food and are extensively hunted with guns by day and with torches and clubs by night.

The coot, *Fulica americana,* is a more aquatic bird than the rails. It is found on rivers, sounds, ponds and lakes swimming about in small flocks like ducks. The toes are fringed but not completely webbed.

The true crane family, *Gruidæ,* consists of large heron-like birds with long necks and legs. The trachea is in some species twice as long as the neck and lies coiled up in the keel. Most of the species of cranes are found in the Old World, but three species occur in North America. These species were formerly very abundant in the great Mississippi Valley, but their numbers have been greatly reduced.

The *Family Alcidæ* includes the auks, murres and puffins. These birds are primarily sea birds that nest often in great colonies on isolated rocky islands and rocky cliffs. For the most part they are peculiar birds of small or medium size with the legs set far back so that when they are at rest they sit nearly upright. Most of the species have thick heavy bills. All the members of this family are excellent swimmers and divers.

The *Family Laridæ* includes the gulls and terns. These birds are often called sea swallows because they are so expert on the wing. They feed on fish for the most part. Most of the gulls and terns are white or grayish-white in color with the crown of the head and the tips of the wings black. The black tern, *Hydrochelidon nigra,* however, is uniform slaty black. The gulls average larger than the terns. They are not as expert on the wing as the terns but are better swimmers and venture further from the land than terns. Both gulls and terns nest in colonies, usually on bare rocky or sandy islands or shores. There are about 100 species in all parts of the world, about one-half of which occur in North America.

The *Family Charadriidæ* includes the snipes, the sandpipers, the curlews, the plovers and related forms (Fig. 20). They are sometimes called shore birds but many of the species live in upland meadows far from the shore. This is a fairly large family of somewhat diverse appearances, but as a general thing the bill and legs are long. They feed for the most part on worms and insects which they find by probing the soft mud along the shores of ponds, lakes and streams and are especially abundant at low tide along the ocean front feeding on beach fleas and worms. Some of the species are famous game birds; the woodcock, *Philohela minor*, of the woods, the sandpipers of the ocean front and the plovers of the upland meadows. Most of the species make no nest save a slight depression in the ground sparingly lined with grass or feathers or without any lining at all.

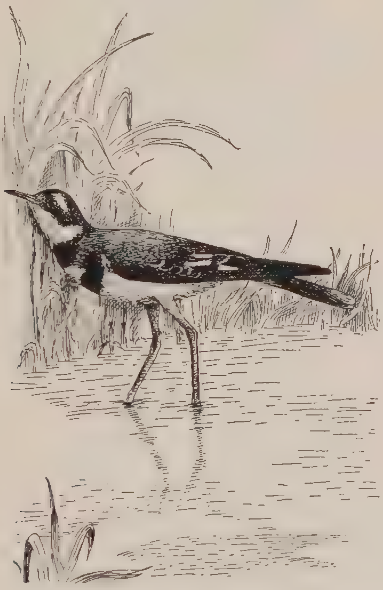


FIG. 20.—Killdeer. *Oxyechus vociferus.* (After Snyder.)

The *Family Columbidæ* includes the doves and pigeons. These birds have a characteristic appearance and are not usually confused with any other birds. They are of small to medium size and are world-wide in their distribution. All the members of this family feed on fruit or seeds. They feed their nestlings by regurgitation, and in drinking these birds stick the bill in the water and suck it up in a continuous draught. The nest is built of small twigs on the ground or a loose platform in low bushes or trees. The eggs are white and only two are laid in a nest.

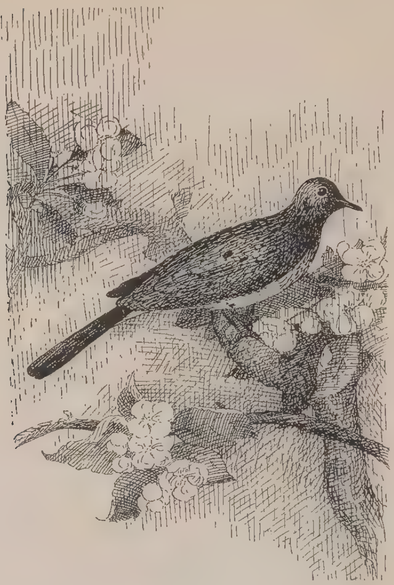


FIG. 21.—Mourning dove. *Zenaidura macroura carolinensis.* (After Snyder.)

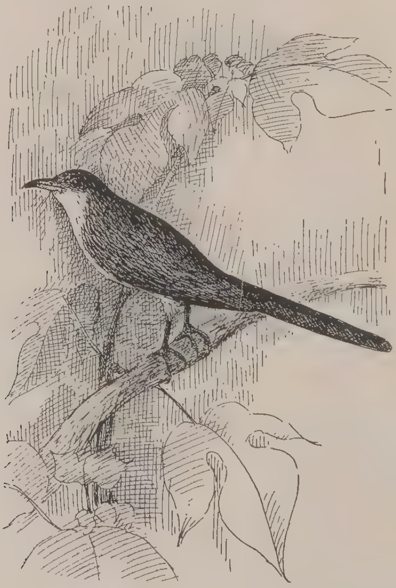


FIG. 22.—Cuckoo. *Coccyzus americanus.* (After Snyder.)

The mourning dove, *Zenaidura macroura* (Fig. 21), has a plaintive mournful call. It is widely distributed over North America, nesting throughout the United States and southern Canada and wintering from the southern half of the United States southward. Mourning doves are usually found in pairs during the breeding season. After the breeding season is over they gather in flocks and feed in grain fields.

The passenger pigeon, *Ectopistis migratorius,* was formerly abundant in eastern North America, occurring in vast flocks but it is now extinct.

The ground dove, *Chæmepelia passerina,* is a very small dove occurring in the South Atlantic and Gulf States.

The *Family Cuculidæ* includes the cuckoos, the ani, and the road-runner. The members of this family are long, slender birds with long wings, a long tail, bill usually slender, sometimes stouter, feet with two toes in front and two behind.

The cuckoos, *Coccyzus spp.* (Fig. 22), are more generally known as "rain crows" from their habit of uttering their peculiar cry during wet weather. Our American cuckoos do not lay their eggs in other birds nests as the European cuckoos do, but build a loose platform of small twigs in bushes and trees. The cuckoos feed mainly on insects, especially caterpillars, and are very beneficial to agriculture.

The ani, *Crotophaga ani,* occur in the West Indies, Mexico and southward into South America. These birds wander northward to the southern United States occasionally. They are of interest because in most species several females apparently lay their eggs in a sort of community nest.

The road-runner or chaparral cock, *Geococcyx mexicanus,* is a bird of the arid southwest. It is a long slender bird with a tail as long as the body. It lives in a region of cactus, rattlesnakes, lizards and grasshoppers. Many strange tales have been told about this bird, such that it feeds only on rattlesnakes, that it builds a fence of cactus about a sleeping rattlesnake, which finding itself fenced in bites itself to death, after which the road-runner devours the snake. This bird feeds on grasshoppers, mice, lizards and small snakes.

The parrots inhabit the tropical and warm temperate regions of the world. They vary in size from small to medium large and are generally fairly well known because they have been extensively used as cage birds. Many of the species have brilliant colored plumage but some are dull gray or brown in color. The bill is generally thick and heavy and the upper bill extends beyond the lower bill and is hooked over it. The feet have two toes in front and two behind. The tongue is usually thick and several species may be taught to speak words or phrases. These birds are not strong fliers but all are excellent climbers, using the bill like a third foot. They feed on fruit, seeds and nuts.

Only one species, the Carolina paroquet, *Conuropsis carolinensis*, occurs in the United States. It formerly ranged northward to the Potomac and Ohio Rivers and westward to the Rocky Mountains, but is perhaps restricted at the present time to the more isolated parts of Florida.

The cockatoos, *Cacatua spp.*, are found chiefly in the East Indies, New Guinea and Australia. They are fairly large birds, usually white in color, with a crest of erectile feathers. They are easily tamed and are good talkers.

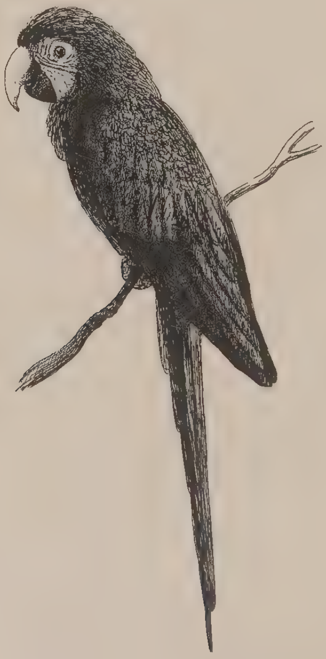


Fig. 23.—Macaw. *Ara sp.*

The love birds, *Psittacula spp.*, are very small parrots from the African region. They are frequently kept for cage birds because of their bright colors, soft cooing voices and their affectionate dispositions.

The African gray parrot, *Psittacus erithacus*, is usually considered the best talkers of the group and are much prized for this ability in spite of their dull grayish plumage.

The macaws, *Ara spp.* (Fig. 23), are the largest of the parrots as well as the gayest colored. Blues, reds, yellows and greens predominate. They are found from Mexico southward to Argentine. They are noisy birds but do not make good talkers.

The *Family Alcedinidæ* is represented by a single North American species, the belted kingfisher, *Ceryle alcyon* (Fig. 24). It breeds from the southern United States to northern Canada and winters from the southern United States to northern South America. This bird is a familiar object along streams and around ponds as it sits quietly on a dead limb or hovers on rapidly beating wings over some quiet pool, suddenly darting downward to emerge with some small fish in its sharp-pointed bill. The nest is a hole in a bank, often dug to a distance of 6 feet or more.

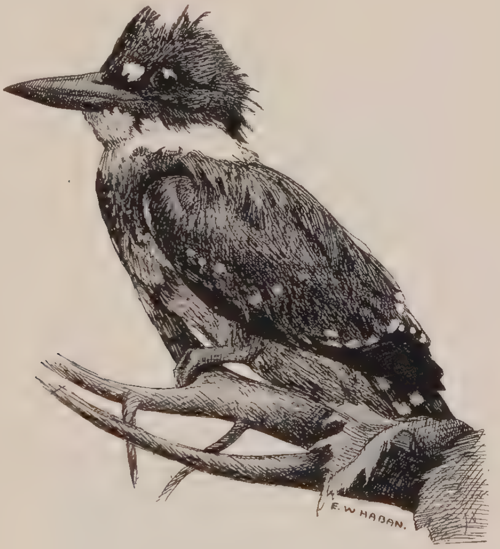


Fig. 24.—Kingfisher. *Ceryle alcyòn.*

The *Family Strigidæ* includes the owls. These are chiefly nocturnal birds of prey with large heads, large eyes, strong hooked beaks, soft feathers and strong talons. They feed principally upon rodents but also eat other mammals, birds, reptiles, insects, snails, etc. This family includes more than 200 species, which are found in all parts of the world. About 20 species are found in America.

Our more common and familiar owls include the barn owl or monkey-faced owl, *Aluco pratincola*, which nearly always creates a good deal of excitement when it is captured, because people believe that it is half bird and half monkey; the barred or hoot-owl, *Strix varia*, which is famous for its weird cry; the great horned owl, *Bubo virginianus*, which has conspicuous ear tufts, and the northern snowy or white owl, *Nyctea nyctea*, which nests in Canada but occasionally wanders down to the northern United States. The smaller owls include the screech-owl (Fig. 25) whose blood curdling

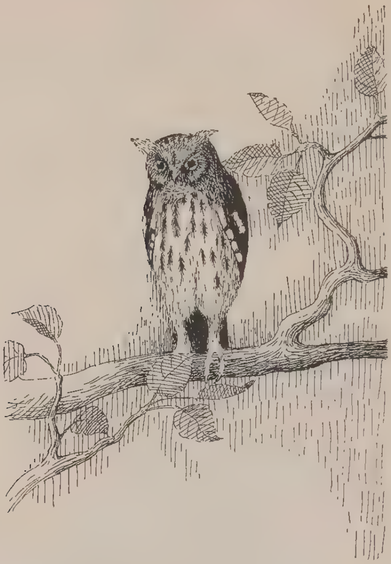


Fig. 25.—Screech-owl. *Megascops asio.* (After Snyder.)

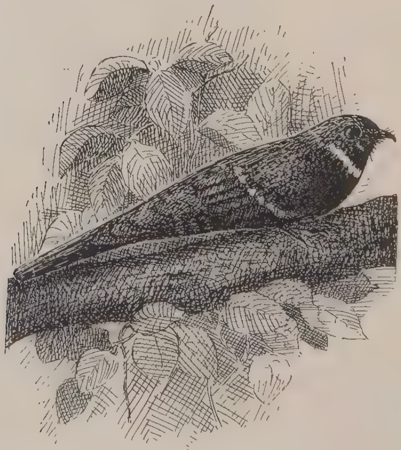


Fig. 26.—Whip-poor-will. *Antrostomus vociferous.* (After Snyder.)

screech is familiar to most people who live in the country. It frequently comes near dwellings to live in a natural cavity in an orchard tree. The burrowing owls inhabit the treeless regions from the

Great Plains to the Pacific. They live in the abandoned burrows of prairie-dogs or dig burrows for themselves. The pigmy owls and the elf owls are very small owls found in western North America.

The *Caprimulgidæ* includes the so-called goatsuckers, which, according to popular superstition, feed by milking goats. This family includes the night-hawk, *Chordeiles virginianus,* bull bats or nightjars, and the whip-poor-wills, *Antrostomus spp.* These birds are chiefly nocturnal, flying during the evening and morning hours and catching insects on the wing. They are medium-sized. The bill is weak and the gape is large, usually fringed by long bristle-like feathers. The wings are long and these birds excel in their ability to dodge by changing the direction of their flight. For this reason some of the species are called bull bats. The whip-poor-wills (Fig. 26) are famous for their peculiar cries, which are repeated over and over again and resemble such syllables as poor-will, whip-poor-will, and chuck-wills-widow. These syllables are used in various parts of the country for different species of these birds. These birds, as a group, construct no nests. The eggs are laid on the bare ground, or on leaves in the woods, or occasionally on the flat-topped roofs of buildings.

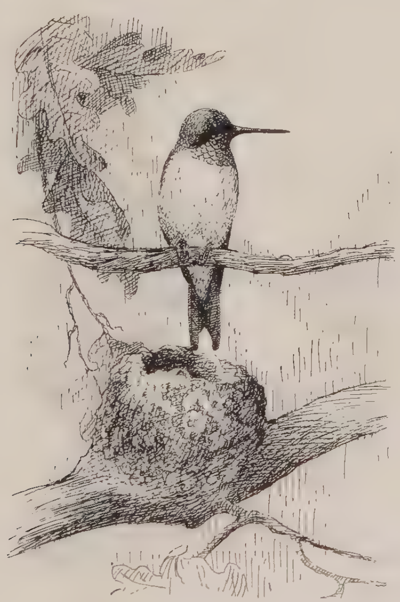


Fig. 27.—Humming-bird. *Archilochus colubris.* (After Snyder.)

The humming-birds, *Family Trochilidæ* (Fig. 27), are found only in the Americas. They are most abundant in the tropics, and are the smallest of our birds. The males are frequently provided with feathers with bright metallic luster. Sometimes the tail is long and slender, sometimes deeply forked, sometimes provided with a pair of elongate feathers. In some cases the crown is provided with erectile feathers. The bills are long and slender as a rule and the feet are weak, as these birds spend most of the time on the wing. The wings beat with great rapidity. They feed on insects and nectar. The nests are usually beautiful cup-shaped affairs attached to twigs or sometimes to leaves and decorated with lichens or moss.

The *Family Micropodidæ* includes the swifts (Fig. 28). They are practically world-wide in their distribution, being most abundant in tropical America and India. Only 4 species are found in North America. They are commonly called swallows, which they resemble in flight, but they differ from the swallows in a number of important ways. The bill is short and the gape is very broad. The wings are long and pointed, the feet are weak, the tail is short and in many species the quills are stiff and end in sharp-pointed spines. The nesting habits of many of the swifts are interesting. They nest for the most part in hollow trees, chimneys, on cliffs or in caves. The nest may be constructed of twigs or other plant material glued together with the gelatin-like saliva, or it may consist entirely of the saliva. The nest may be a simple cup-like structure as in our common North American chimney swift, *Chaetura pelagica*, which formerly nested in hollow trees, or it may be a very elaborate struc-

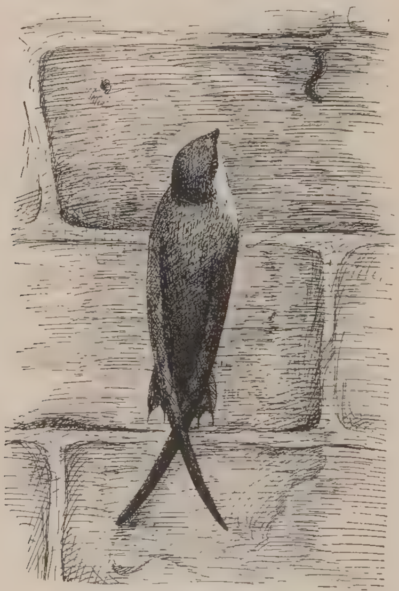


Fig. 28.—Chimney swift. *Chaetura pelagica.* (After Snyder.)

ture as it is in the Central American swift. This swift constructs a tube about 2 feet long which is made by gluing together the seeds of a Central American plant. This tube is built attached by one end to an overhanging cliff, the other end is left open as an entrance. The eggs are laid in a cup-like depression near the upper end of the tube.

The swiftlets of the Oriental and East Indian regions build nests composed entirely of gelatinous saliva, the so-called edible bird nests which are collected and used by the Chinese and others to make bird-nests soup.

The *Family Picidæ* includes the woodpeckers. These birds are largely arboreal, feeding chiefly on wood-boring larvæ and ants and building their nests by making a tunnel in the dead limb or trunk of a tree. The beak is stout and used for drilling holes in trees in search of wood-borers or for building nests. The tongue is long and can be extended a considerable distance beyond the tip of the bill to spear their prey. The tail feathers are rigid and are used to prop the bird against the tree as it creeps about on the trunk of a tree in search of food. Woodpeckers are found chiefly in tropical America and India, but are entirely absent from Australia. About 25 species are found in North America. They are small to medium-sized birds, usually conspicuously colored black and white with brilliant patches of red on the head and neck. One of our North American species is a true sapsucker, *Sphyrapicus varius*, and drills many holes in the bark of trees, feeding on the exuding sap and to a certain extent on the insects which are attracted to the fermenting sap. In this way it is sometimes injurious to orchard, ornamental and woodland trees. The little downy woodpecker, *Dryobates pubescens* (Fig. 29), of the orchard is sometimes called sapsucker, but it feeds on insects. The flicker or yellowhammer, *Colaptes auratus*, and the brilliantly colored red-headed woodpecker, *Melanerpes erythrocephalus*, are familiar woodpeckers of eastern North America. The ivory-billed, *Campephilus principalis*, and the pileated woodpeckers, *Phlœtomus pileatus*, are the largest of our North American woodpeckers. They are both solitary birds of the deep woods and are seldom seen. All our woodpeckers have characteristic calls but nothing that could be called a song. Many species have the habit of drumming by rapidly tapping the bill on a dead limb, and the performance of a woodpecker on the metal flashing of a roof would do credit to a kettle drummer. In addition to the injury caused by the sapsucker some of our species are injurious by drilling nesting holes in telegraph and telephone poles, thereby weakening the poles so that they break during storms.

The order *Passeriformes* is the largest order of birds, as it includes about one-half the known kinds of birds. This order includes all our well known song birds. About the only character that seems to

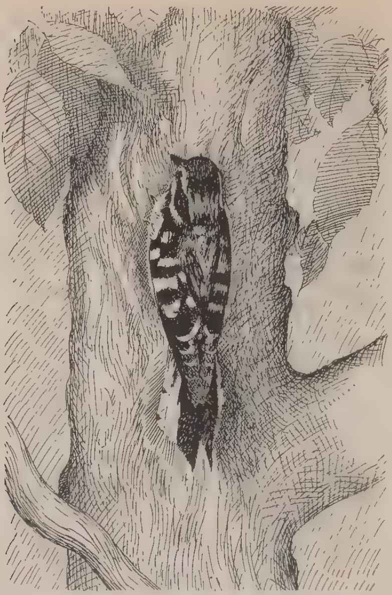


FIG. 29.—Downy woodpecker. *Dryobates pubescens.* (After Snyder.)

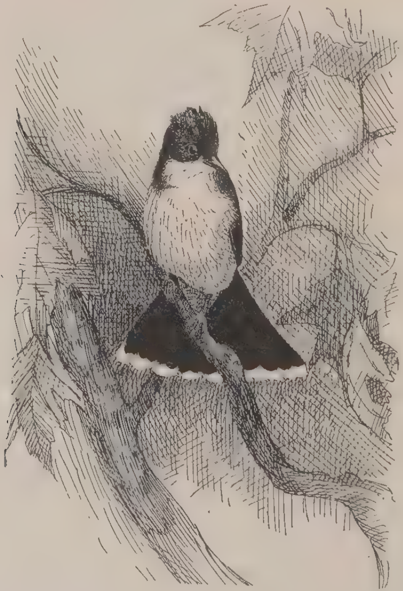


FIG. 30.—Kingbird. *Tyrannus tyrannus.* (After Snyder.)

be common to all species is the presence of four toes, three in front and one behind, the fourth toe on the same level as the others. Only brief notes on the larger and better known North American families are included here.

The *Family Tyrannidæ* or tyrant flycatchers includes small or medium-sized, dull-colored birds with poorly developed voices. They are all fly catchers in that they have the habit of perching on an exposed limb and darting out to capture insects on the wing. Some of these birds are very pugnacious and do not hesitate to attack and drive larger birds away from their nests. The kingbird, *Tyrannus tyrannus* (Fig. 30), has received its common name from this habit. Many a large hawk or owl has retreated in haste before the onslaught of one of these daring little fellows that does not hesitate to dart down and deliver a sharp peck on the head or back of its larger, more clumsy opponent. The phœbe, *Sayornis phœbe,* and the pewee, *Myiochanes virens,* are flycatchers, named from their peculiar, plaintive cries. The scissor-tailed flycatcher, *Muscivora forficata,* of the southwest is one of the larger flycatchers, with deeply forked tail. The nests are generally saddled on a horizontal limb, but the phœbe nests on banks or walls or on the timbers of bridges and buildings. The great crested flycatcher, *Myiarchus crinitus,* nests in knot holes in trees with a cast snake skin for an ornament. The nest of the pewee is a work of art, being a deep cup like a large humming-bird's nest and ornamented with lichens and moss.

The *Family Alaudidæ* is an Old World group which includes that famous European song bird, the skylark, *Alauda arvensis.* In North America there is a single species, the horned lark, *Otocoris alpestris,* which nests from the northern United States northward to Arctic America, Europe and Greenland, migrating southward in winter. They are dull-colored ground-loving birds that occur in flocks in open fields in winter.

The *Family Corvidæ* includes the crows, magpies and jays. These are large or medium-sized birds, commonly occurring in small flocks which together with their noisy habits and their lack of fear of man makes them among our best known birds. The crows, *Corvus spp.* (Fig. 31) and the raven, *Corvus corax,* are solid black in color. The raven differs chiefly in being larger and more retiring than the crow. It is found in North America only in the Arctic region and the higher mountains. The jays are usually grayish or bluish slate color with a distinct crest. The magpie, *Pica pica,* is a bird of western North America. It resembles a jay somewhat but has a much longer tail and is marked with black. All the members of the crow family are omnivorous feeders, eating practically anything that woods or fields afford.

The starling, *Sturnus vulgaris* (Fig. 32), was introduced in New York from Europe about 1890. Since that time it has spread until

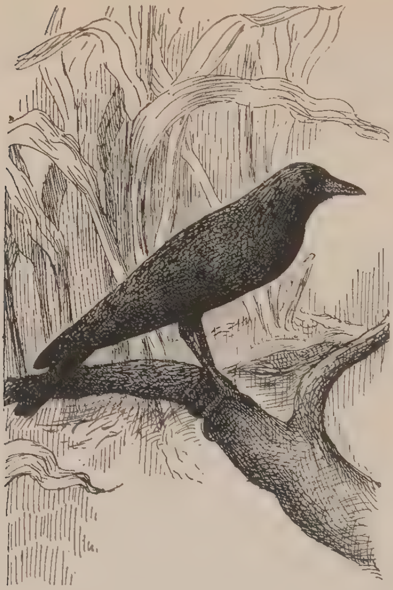


Fig. 31.—Crow. *Corvus brachyrhynchos.* (After Snyder.)

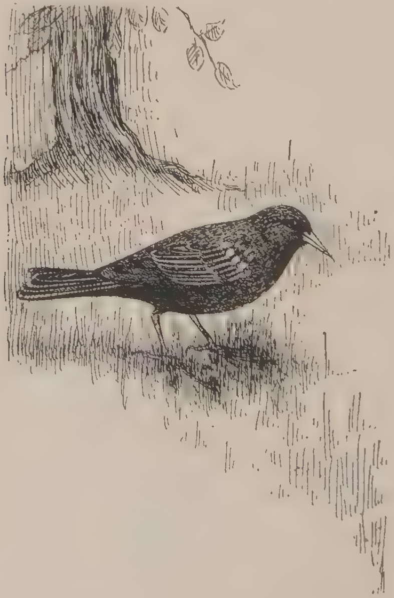


Fig. 32.—Starling. *Sturnus vulgaris.* (After Snyder.)

at the present time it occupies most of the Atlantic Seaboard and westward to the Ohio Valley. It has increased rapidly during the last few years and promises to be a nuisance in cities where it roosts in trees and fouls the streets. This bird may be recognized by its short, thick-set body, the plumage of the adult being dark with metallic purplish and greenish luster. The starling walks on the ground and does not hop as so many of our ground birds do. Careful examination of the stomachs of numerous birds shows that more than one-half its food consists of insects and millipeds; that it eats large amounts of garbage and wild fruit; and that it is often destructive to cultivated cherries. This bird nests in crevices about buildings and in woodpecker holes.

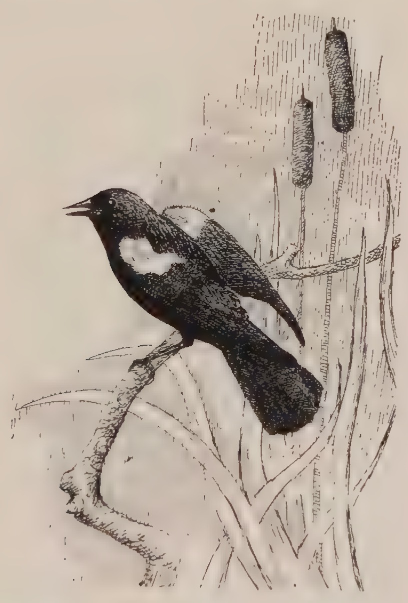


Fig. 33.—Red-winged blackbird. *Agelaius phœniceus.* (After Snyder.)

The *Family Icteridæ* includes the blackbirds, the grackles, the orioles and the meadow-lark. This family is confined to the Americas but most of the species are tropical. For the most part our species are gregareous, often occurring in immense flocks. Some species live in wooded regions, others in open fields or prairies and others in marshes. As a general proposition these birds are beneficial, feeding on insects or weed seeds. Some forms are injurious, feeding on grain, and large flocks of these birds often do great damage to sprouting or ripening grain.

The blackbirds are small-sized birds with the males nearly uniformly black with bright markings, and the females rusty brown streaked with blackish. The red-winged blackbird, *Agelaius phœniceus* (Fig. 33), has the shoulders bright red with a buff border. The yellow-headed blackbird, *Xanthocephalus xanthocephalus*, has the head and neck bright yellow. The cowbird, *Molothrus ater*, has the head and neck brown. The bobolink, *Dolichonyx oryzivorus*, has the nape of the neck and the back marked with buff and white. The grackles are larger blackbirds with metallic luster and long tails. They are commonly called crow blackbirds. The orioles, *Icterus spp.*, are black with markings of red, orange and yellow. The meadow-larks, *Sturnella spp.*, are grayish-brown birds with the throat and breast bright yellow with a black crescent.

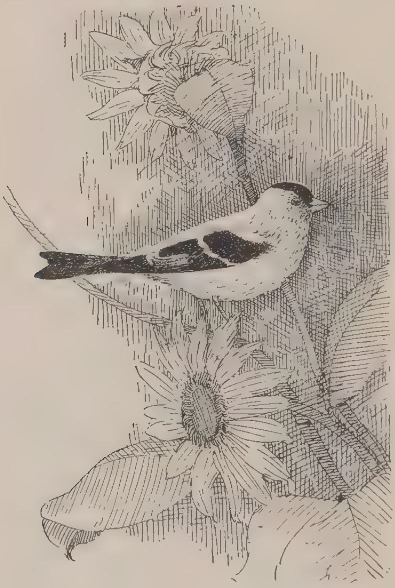


FIG. 34.—Goldfinch. *Astragalinus tristis.* (After Snyder.)

The cowbird lays its eggs in the nests of other birds leaving the incubation and the rearing of the young to the foster parents. The orioles build beautiful pendant nests in trees. The blackbirds build nests in cattail marshes. The meadow-lark and the bobolink build on the ground and the grackles in trees.

The *Family Fringillidæ* includes the finches, the crossbills, the sparrows, the grosbeaks and the buntings. This is one of the largest families of birds and is found in all parts of the world except Australia. These birds are generally of small size with short wings and tails, and stout beaks adapted for crushing seeds.

The number of species is so great in this family that only the more conspicuous members can be mentioned briefly. The purple finch, *Carpodacus purpureus*, is a brownish bird with the head, neck and back reddish. It nests from the northern states northward and winters throughout the United States. It is often destructive in orchards by eating the buds.

The goldfinch, *Astragalinus tristis* (Fig. 34), is a bright yellow bird with cap, wings and tail black. It feeds on the seeds of the thistle and sunflower family principally.

The crossbills, *Loxia spp.*, are northern birds that have the mandibles crossed. They feed on the seeds of coniferous trees.

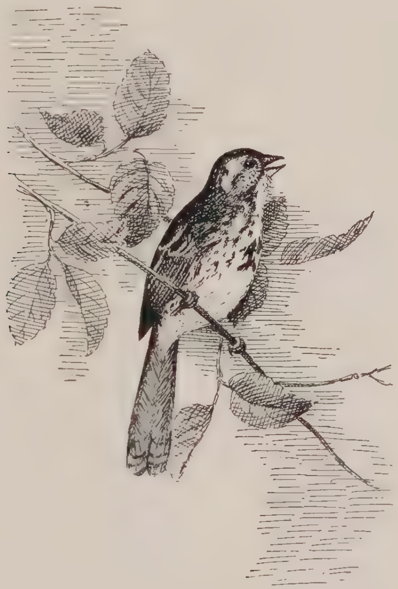


FIG. 35.—Song-sparrow. *Melospiza melodia.* (After Snyder.)

The sparrows are brownish or grayish-streaked birds, usually without conspicuous markings. Although the vesper sparrow, *Poœcetes gramineus*, has white outer tail feathers, conspicuous in flight, and the white-crowned, *Zonotrichia leucophrys* and white-throated sparrows, *Zonotrichia albicollis*, have the head conspicuously streaked with white and black. Our native sparrows are chiefly birds of open fields and meadows or thickets. They are generally beneficial, feeding on weed seeds and insects. About 50 species are known in the United States. The more familiar include the chipping sparrrow, *Spizella passerina*, of the door yard, the field sparrow of the thickets, *Spizella pusilla*, the song-sparrow, *Melospiza melodia* (Fig. 35), of the meadows and the tree or winter sparrow, *Spizella monticola.*

The English sparrow, *Passer domesticus*, was introduced into the United States about 1850. Since that time it has spread all over the United States and has become a general nuisance about poultry yards, on farms and in the cities, although the passing of the horse has greatly reduced its numbers in cities and towns. It is a noisy, quarrelsome fellow with filthy habits and while it eats some insects the amount of grain and feed that it eats far outweighs the good it does.

The junco or snowbird, *Junco hyemalis*, is a slate-colored bird with conspicuous white outer tail feathers. It nests from the northern states northward and in the higher mountains. It is one of our most familiar winter residents in the United States, often coming about houses and barns in large numbers seeking food, especially when the ground is covered with snow.

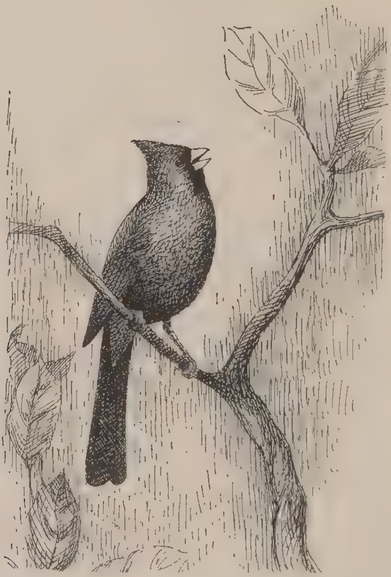


Fig. 36.—Cardinal. *Cardinalis cardinalis*. (After Snyder.)

The grosbeaks are the largest of the finch tribe and include some of the brightest and best singers. This group includes the cardinal or red bird, *Cardinalis cardinalis* (Fig. 36), with bright red plumage, with a black spot at the base of the bill and conspicuous crest. Its clear whistle is familiar to everyone and it was formerly much used as a cage bird. The rose-breasted grosbeak, *Zamelodia ludoviciana*, is conspicuously black and white with the breast and under wings bright rosy red. Its song resembles the song of the robin. The blue grosbeak, *Guiraca cœrulea,* is dull blue in color and occurs in the southern United States. The towhee, joree or ground robin, *Pipilo erythrophthalmus,* receives his common names from his call note or from his general resemblance to a robin. He is a bird of the thicket and spends most of his time on the ground scratching among the leaves for food.

The buntings are smaller than the grosbeaks. Our commonest species is the indigo bird, *Passerina cyanea,* which is deep blue in color and is a summer resident in eastern North America. It is usually most abundant along bushy roadsides and the males are conspicuous, sitting on telephone wires and singing a continuous canary-like song. The painted bunting, *Passerina ciris,* is one of our brightest-colored birds. The head and neck are deep blue, the under parts bright red and the back green. It breeds in the Southeastern United States and winters in the tropics.

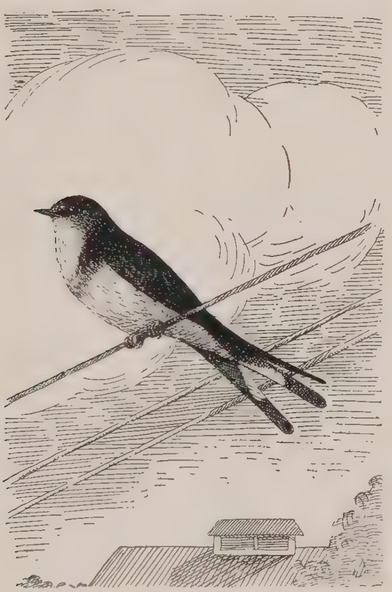


FIG. 37.—Barn-swallow. *Hirundo erythrogaster.* (After Snyder.)

The tanagers are peculiar to the Americas but practially all of the 350 species are found in tropical South America, as only 5 species migrate northward to nest in the United States. Our species, *Piranga spp.,* are bright red birds with darker wings and tails. They live in the woods and feed on fruits and insects for the most part.

The swallows, *Family Hirundinidæ,* are masters of the air, being birds with long wings and usually long tails which are often deeply forked. They live exclusively on insects which they capture on the wing. The gape is wide and the feet weak. The back is generally metallic blue or black, sometimes brownish in color, the under parts lighter. The swallows are distributed throughout the world. Their nesting habits are diverse. The purple martin, *Progne subis*, nests in bird houses. The cliff swallow, *Petrochelidon lunifrons*, and barn swallow, *Hirundo erythrogaster* (Fig. 37), build nests of mud about buildings on the rafters or under the eaves or on cliffs. The tree swallow, *Iridoprocne bicolor*, builds its nest in a hollow tree and the bank swallows dig a tunnel 2 or more feet deep and place the nest at the end of the tunnel.

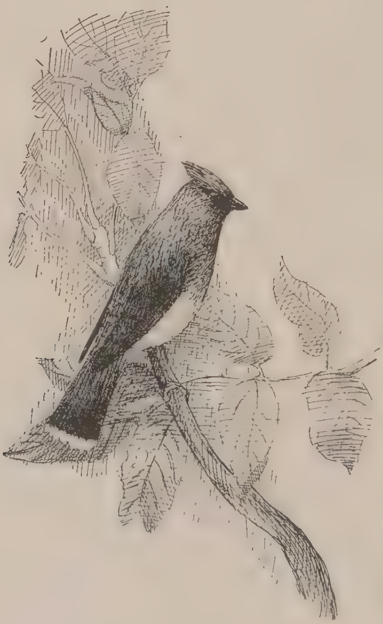


Fig. 38.—Waxwing. *Ampelis cedrorum.* (After Snyder.)

The *Family Bombycillidæ* includes the waxwings (Fig. 38). This is a small family of 3 species confined to the Northern Hemisphere. All the species have peculiarly modified feathers on the wings which resemble drops of sealing wax, hence the name waxwings. These birds are the gypsies of the bird world wandering irregularly about at all seasons of the year.

The shrikes, *Family Laniidæ* (Fig. 39), are found chiefly in the Old World, only 2 species being found in North America. They are perching birds with the hooked beak and strong talons of the birds of prey with hawk-like habits. They feed on large insects, mice and small birds. They have the habit of impaling their prey on the thorns of the thorn bush or the barbs of a barbed-wire fence, hence the name butcher bird. Their song is varied and mockingbird-like but harsh and unmusical, hence the name French mockingbird.

The vireos, *Family Vireonidæ* (Fig. 40), are limited to the Americas, being found chiefly in Central and South America. They are small birds, generally olive-green above, lighter below, hence they are frequently called greenlets. They spend all their time in trees, especially at the tips of the branches searching for small insects on the bark and leaves. Most of our species are persistent singers repeating their rather monotonous songs all day long. Their nests are beautiful cup-shaped structures made of strips of bark and plant fibers suspended between the forks of the outer limbs of a tree and are often ornamented with lichens.

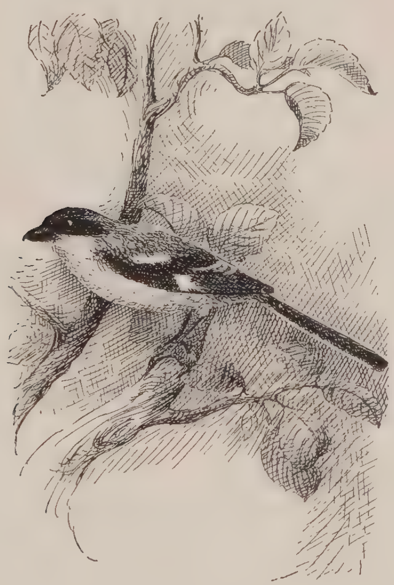


FIG. 39.—Shrike. *Lanius ludovicianus*. (After Snyder.)

The wood-warblers, *Family Mniotiltidæ* (Fig. 41), constitute a large family of strictly American birds. About three-fourths of the 100 odd species nest in North America. They are for the most part small or very small birds, often brilliantly marked with bright yellow, orange or red. Some of the species are olive-green in color and might be confused with the vireos and some are conspicuously black and white. These birds live primarily in the woods or in thickets and feed on small insects. Their nesting habits are various. Some nest

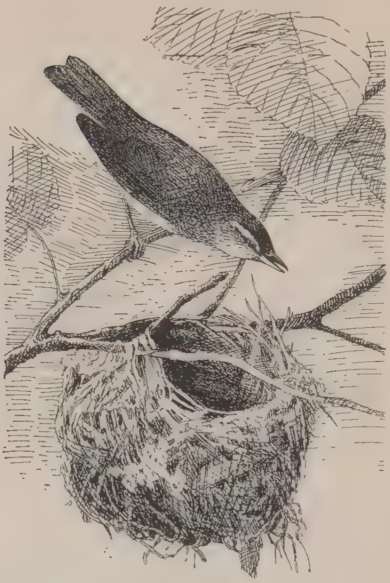


FIG. 40.—Red-eyed vireo. *Vireosylva olivacea.* (After Snyder.)

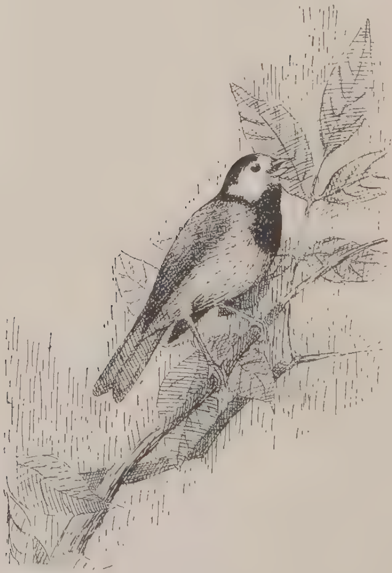


FIG. 41.—Hooded warbler. *Wilsonia citrina.* (After Snyder.)

on the ground, others in holes in trees, others build saddle-shaped nests in trees. The parula warbler, *Compsothlypis americana*, builds its nest in the long spanish or gray moss hanging from the limbs of trees. These bright little birds make up the bulk of the hordes of migrating small birds in the early spring and their bright colors make them favorites with bird students.

The wrens, *Family Troglodytidæ* (Fig. 42), are a family of small birds. Most of the species live in tropical America but about 17 species are found in North America. They are for the most part brown birds, with barred wings and tails, slender bills, short, rounded wings and short tails held vertically. They live in thickets and marshes. They build bulky nests in holes in trees, about buildings in crevices of rocks or in bird houses. The marsh-wrens build globular nests attached to cattail stalks. They have the peculiar habit of building several nests but occupying only one. The wrens feed largely on insects and as many species are sociable, nesting about houses, they are valuable birds in the control of insects of the orchard and garden.

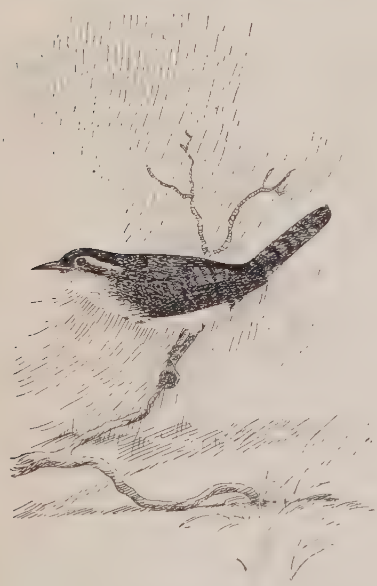


Fig. 42.—Carolina wren. *Thyrothorus ludovicianus.* (After Snyder.)

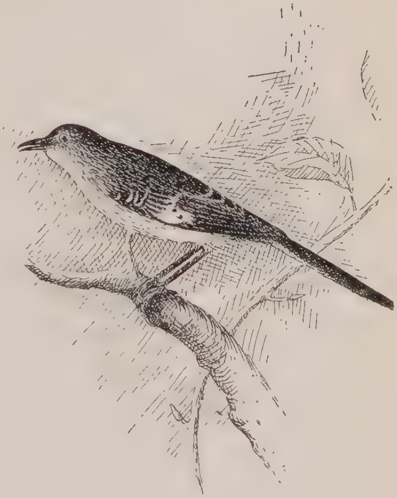


Fig. 43.—Mocking-bird. *Mimus polyglottos.* After Snyder.)

The *Family Mimidæ* includes the thrashers, the catbird and the mocking-birds (Fig. 43). As a general rule these are elongate birds with long bills and long tails. They are, for the most part of dull plumage, brownish or grayish slate color. What they lack in bright colors they make up in song, as all the members of this family are brilliant songsters. Their songs have a general resemblance, being long continued and containing varied notes suggestive of the notes of other birds. These birds live commonly in thickets and build their nests on or near the ground. All are insect eaters of great importance and are deserving of protection.

The *Family Certhiidæ* includes the creepers (Fig. 44) which might be defined as woodpeckers without the chisel-like beaks. They have the same general habit of creeping up the trunks of trees, using their stiffened tails for support. They feed, however, upon whatever insects they find in cracks and crevices of the bark and not on wood-boring larvæ. This is a family of birds with few species which are, however, widely distributed. Four species occur in North America. The most familiar being the brown creeper, *Certhia familiaris*, which nests from the United States northward and winters from Canada to the Gulf States.

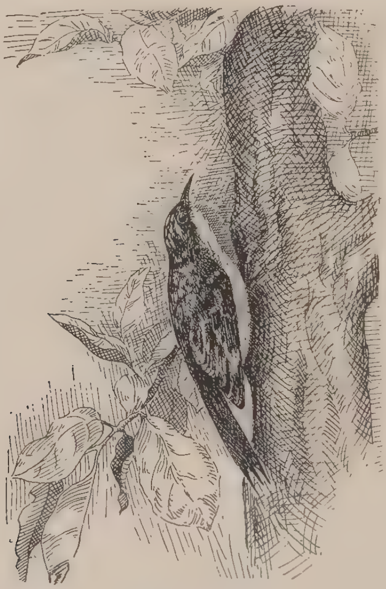


Fig. 44.—Brown creeper. *Certhia familiaris americana.* (After Snyder.)

The *Family Sittidæ* includes the nuthatches (Fig. 45), a small group of birds including about 20 species from various parts of the world, 4 species being found in North America. They are short, compact birds with long, sharp-pointed beaks, long wings and short tails. They have the habit of searching for insects on the trunks and larger branches of trees, often hanging head down. They feed not only on insects but also on nuts and seeds. Our species are

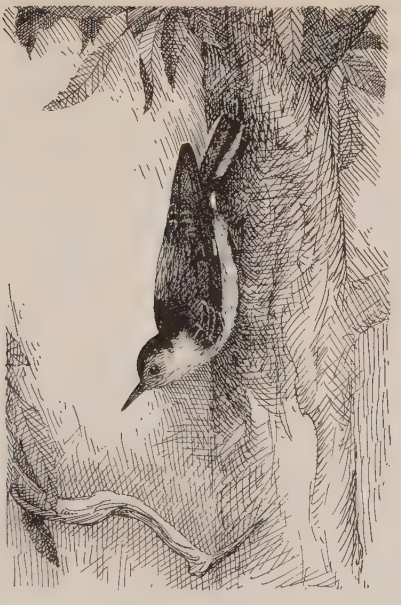


FIG. 45.—Nuthatch. *Sitta carolinensis.* (After Snyder.)

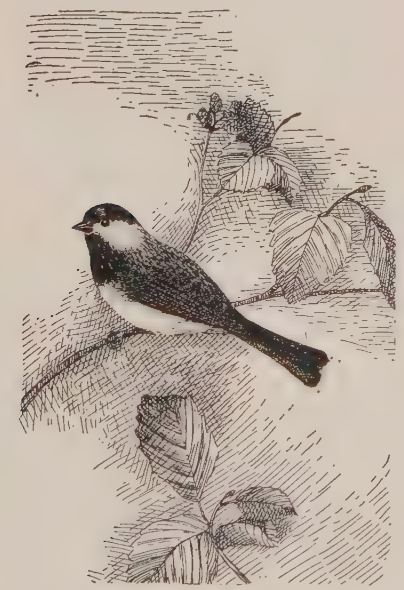


FIG. 46.—Chickadee. *Penthestes carolinensis.* (After Snyder.)

bright slaty blue above, lighter beneath. They nest in natural holes in trees, abandoned woodpecker holes, and holes they construct themselves.

The *Family Paridæ* includes small active birds generally called tits or titmice, and including the chickadees (Fig. 46) and the bush tits. These birds are generally dull colored but they are very active and as they are generally busy during the cold months of winter they usually attract considerable attention. They seem to be equally at home right side up or upside down as they search for small insects and their eggs among the smaller branches of trees. The titmice and the chickadees nest in holes in trees and stumps, either abandoned woodpecker holes, natural cavities or holes they dig for themselves. The bush-tits which occur in the Western States build a bulky, purse-shaped nest out of moss which they suspend from a low limb. The entrance to the nest is near the top on one side.

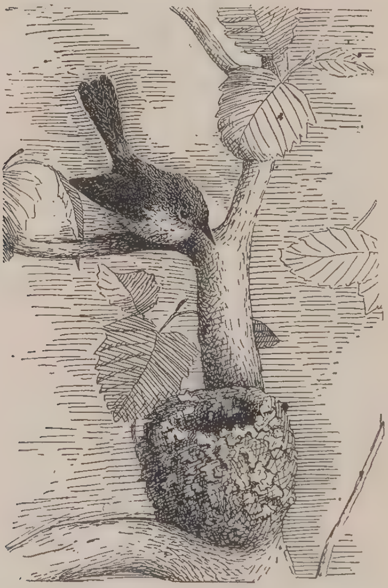


FIG. 47.—Blue-gray gnatcatcher. *Polioptila caerulea.* (After Snyder.)

The *Family Sylvidæ* includes the warblers, kinglets and gnatcatchers (Fig. 47). They are small or very small active birds feeding for the most part on small insects which they gather from leaves and twigs. Our species are mostly dull-colored but the kinglets have bright-colored crown patches. The kinglets nest from the northern United States northward, wintering throughout the

United States. The nest of moss and bark is generally pendant. The gnatcatcher winters chiefly south of the United States and nests generally throughout the eastern United States. The nest is a delicate cup-shaped structure saddled on a limb and ornamented with lichens, resembling a large humming-bird nest.

The *Family Turdidæ* includes the thrushes, robins and bluebirds. It is a large family with between 300 and 400 species distributed throughout the world, but only 12 or 15 species are found in North America. The robin, *Planesticus migratorius*, and bluebird, *Sialia sialis,* are both too well known to need description. They nest commonly in gardens and orchards. The former on horizontal limbs or beams in buildings, building a bulky, cup-shaped nest lined with mud. The latter in bird houses or natural cavities. The thrushes (Fig. 48) are generally about the size of a robin, brownish above, lighter below with the breast streaked or spotted. They are wood-loving birds. Several species are famous for their beautiful songs which are sung principally in the evening or early morning hours. No finer experience can come to the student of birds than the opportunity to listen to the clear liquid songs of the wood-thrush and the hermit thrush as they sing deep in the woods in that quiet hour following the setting of the sun on a summer evening.

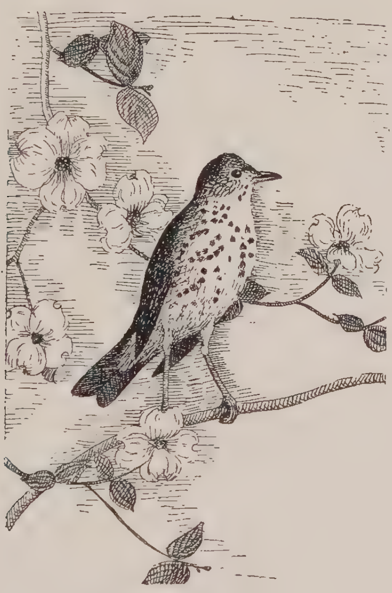


FIG. 48.—A representative perching bird, wood thrush. *Hylocichla mustelina.* (After Snyder.)

CHIEF VALUE OF BIRDS TO MAN.

Birds are of value to man in a number of different ways. The more important of these are the birds that are used as food, or sport. The products of birds are used in a variety of ways, more especially the eggs that are used as food, the feathers that are used for ornament and other purposes, and the guano that is used for fertilizer. Birds are also useful to man as destroyers of some of the most persistent foes of man; such as rodents, insects and the seeds of noxious weeds. Certain birds are of economic importance because they destroy his crops or devour the animals that are useful to man.

Birds That Are Used for Food.—The meat of various birds has long been used for food by man. These fall naturally into two groups, wild birds and domestic birds. Wild birds, of course, are of greatest importance to savage tribes and to settlers in new countries. As tribes become more civilized or as a country becomes more thickly settled the domestic birds become of more and more importance.

The chief requirements of wild birds that are used for food are that they be rather abundant, fairly easy to kill, that they be of some size and that the flesh shall be palatable. Many birds satisfy one or more of these requirements but only a few satisfy them all. Hence, the number of wild birds that are used for food include only a small percentage of the total bird population of the world. Thus, many birds that are palatable are not really large enough to be important sources of food. The sparrows may be taken as an example of this group. Other birds that are abundant enough and easy to secure may not be palatable, this applies to all the flesh-eaters, the fish-eaters and the carrion-eaters. The chief groups that are left among the wild birds are the ducks and geese, and the fowl-like birds such as the quails, grouse, pheasants and turkeys. The shore birds furnish some food but they are of minor importance.

The wild ducks and geese are of only very limited importance as food. They have been so extensively hunted that they were threatened with extinction. They are, therefore, protected by rather stringent laws and are at the present time chiefly of interest to the sportsman. Some of these birds are highly regarded by the epicurean and this applies especially to the canvas-back duck. Much of the reputation of the canvas-back is pure exaggeration as those who are in a position to know state that there are other ducks that are the equal if not the superior of the canvas-back.

The quails and pheasants and their kind were formerly of very great value as food for early settlers but many of the important species of former years are either extinct or reduced to such numbers that they are no longer of real importance. The roll-call of vanished or vanishing birds would include the bob-white in many regions, the ruffed grouse, the heath-hen, the prairie-hen and the wild turkey. The same is true of the passenger pigeon, which belongs to the pigeon family.

The chief domestic bird that is used for food is the domestic fowl or chicken. As has been mentioned it is undoubtedly a descendant of the jungle fowl of India and the East Indian Islands. The original birds were perhaps domesticated by the natives of this region as game-cocks. It is still used for this purpose in India, and of all the various breeds that have been developed since these birds were first domesticated, the game breeds are nearest the original jungle fowl. From such stock as this, consisting of birds of little value for food, and laying only a small number of eggs, man has by selection produced many different breeds. In addition to the game breeds these may be grouped as general purpose breeds, fairly heavy birds suitable as meat animals and laying a fair number of eggs, such for example as the Plymouth rocks. These breeds are the favorites with the back-lot chicken raiser who keeps only a small flock. As meat breeds, heavy-bodied birds laying only a small number of eggs and used chiefly for table purposes, such for example as the Brahmas. As egg-laying breeds, rather light-bodied birds chiefly valued for the large number of eggs that they lay, such for example as the Leghorns. Many breeds have also been developed by the fancier for show purposes or for pets, such as the tiny bantams.

As this country becomes more thickly populated poultry raising becomes more and more important, not only because the hen is an efficient machine for converting grain into meat and eggs but also because a large number of chickens may be kept in a relatively small area.

Many other kinds of birds have been domesticated but none of them have become so widespread or as popular as the domestic fowl. From the pheasant family in addition to the domestic fowl, man has domesticated the turkey, the guinea fowl, the peacock and some Asiatic pheasants; from the pigeon family the domestic pigeon, and from the duck family the ducks and geese. These birds have been developed chiefly for meat, any eggs that they lay beyond what are needed for breeding purposes are purely incidental.

The turkey has been directly derived from the wild turkey of North America. Selection has been chiefly for increased size and also for color. Black, bronze, and white breeds of turkeys have been developed. While the turkey is still a very popular bird, it does not thrive well in confinement and to raise turkeys satisfactorily they must be given an extensive range. Turkey raising is profitable, therefore, only in the thinly populated sections of our country.

The domestic guinea fowl is derived from the wild guinea fowl of Africa. It is a small turkey-like bird with bare head and neck, the feathers are dark with white spots. These birds may be said to be only half domesticated as they do not thrive well in close confinement but require considerable range. The eggs are small and the flesh is dark colored but has a peculiar game-like flavor much prized by some.

The peacock was formerly considered a great delicacy but at the present time it is valued chiefly for its ornamental purposes. It is still extensively used in this way in parks and on large estates.

Certain of the Asiatic pheasants have been domesticated to a certain extent, but these birds are bred largely for game purposes and are used chiefly on large estates and on game reserves.

The domestic pigeon is undoubtedly a descendant from the rock-pigeon of Europe. Numerous varieties have been developed by the fancier, chiefly for show purposes. The young of the pigeon, called squabs, are considered a great delicacy and since pigeons can be raised in rather close confinement, the industry thrives near large cities, where there is a constant demand for squabs.

The domestic ducks are probably descendants of a mixed ancestry, including strains from European and Asiatic species and certainly in some breeds from the American Mallard. Eggs of the domestic duck are placed quite commonly under a brooding hen for hatching and wild duck eggs are frequently treated in the same way, thus perhaps many species have contributed to our breeds of domestic ducks. The duck as an article of diet is relished more in Europe than in America, and in this country is eaten most extensively by the descendants of the peoples from Southern and Eastern Europe. Ducks are raised extensively near the large cities and Long Island Ducks are famous on the markets.

The domestic goose is probably a descendant of the gray goose of Europe. Its feathers are still of great value for pillows, but the flesh of the goose is not considered as good as the flesh of many other domestic birds, being too fat and oily for popular taste.

Birds That Are of Value for Sport.—As regions become more settled birds that were formerly of value as food become chiefly of value as sport. Neither, is this value to be minimized. The healthful exercise to be gained by a day's shooting is of real value. And who can minimize the value to the man of the street of days spent in anticipation and preparation for a day in the beautiful autumn woods hunting for the sly woodcock, ruffed grouse, or wild turkey? Who shall attempt to measure the value of a day across open fields and through tangled thickets behind good dogs hunting for bob-white or quail? What is the value of a day spent in a duck blind behind outspread decoys in the face of a biting northeaster that chills the flesh to the bone but does not chill the enthusiasm? Is it worth while to spend a day on the open beach hunting sandpipers while our minds become saturated with beating waves, scudding clouds and wind-blown sand-dunes? All these things are of value if indulged in for sport. But the sport does not consist entirely of seeing how large the bag of killed game can be made but consists rather of giving the bird some sort of a run for its money and in using moderation in the number killed so that some may be left for seed for next year, and for the years to come. Sportsmen are coming to realize more and more that game deserves a closed season, and that there should be a bag limit. As species after species has become extinct it has gradually dawned on the mind of the sportsman that game will not continue to be plentiful indefinitely, unless it is given proper protection.

Likewise, there has grown up a sentiment for the protection of non-game or song-birds, although there remains much to be done along this line. For small boys, and some boys not so small, still delight in shooting valuable or inoffensive birds for the pure joy of killing. Many birds are killed indiscriminatingly by hunters. Such birds as the grebes, loons, herons, gulls, terns and others have no value for food and are not destructive to man, yet are frequently killed. Hawks and owls are almost universally believed to be destructive to poultry and to game and are killed indiscriminately. Yet, the painstaking investigations of many scientists have shown that only a few species are to be condemned on these counts and that most of our hawks and owls are of great value to man as destroyers of rodents. Nevertheless, the slaughter still goes on. Most of these birds are of some size and we might excuse the mighty hunter on the basis of the thrill he gets from classing himself among the big game hunters. But what is to be said for the hunter who shoots valuable insect-eating song-birds, because he must have a live target? Gradually there is being built up a sentiment against this useless and wasteful slaughter.

Bird Products.—Birds yield a number of products that are of importance to man. The chief ones are eggs, feathers and guano.

Eggs.—The domestic fowl or chicken produces the greater number of the eggs eaten by man, estimated at 2,600,000,000 dozen per year for the United States alone. The other domestic birds yield some return from surplus eggs but the eggs of these birds are used principally for hatching. The species of wild birds that nest in colonies are frequently robbed of their eggs. This is a very wasteful process as the usual method is to visit the colony one day and destroy all the eggs in the colony and then go back the next day and collect the eggs. In this way a fresh supply is guaranteed. Most of the colonial birds being innocuous to man this process has been declared illegal and these birds placed under the protection of state and Federal laws.

Feathers.—Feathers from various species of birds have been used for ornament by different primitive peoples since the beginning of history. Up until the last few years feathers have been used extensively for millinery purposes. And many beautiful birds have been slaughtered for this purpose. At one time it looked as if the egrets, furnishing the aigrettes, the birds of paradise and other birds would become extinct because this barbaric fashion decreed that these birds were fashionable. At this point the Audubon Societies commenced to educate the people against this fashion. Their educational campaign was so effective that stringent laws were passed against the destruction of our native birds and also against the importation of feathers from foreign birds for this purpose. As a matter of fact this campaign over-reached itself, for the wearing of feathers became so unfashionable to most people that they refused to wear even the beautiful ostrich plumes which are cut from the domestic ostrich without injuring it in the least.

The feathers of many species of birds are used also for pillows. The fine down of geese is favored for this purpose but the softer feathers from the duck and the chicken are often used.

Guano.—Guano is a mixture of the excreta of fish-eating birds, dead birds, unhatched eggs and soil. The guano from arid regions is rich in nitrogen, as a matter of fact it is our best source of nitrogenous fertilizers. The chief sources of this material are small islands off the coast of Peru. Mining and the exportation of this guano commenced about the middle of the last century and it is said that more than 500,000 tons were mined each year. In some places the layer of guano was more than 100 feet thick, hence, the supply was thought to be inexhaustible, and the mining operations were carried on along with the ruthless slaughter of the birds. About 1900 it was realized that if this destruction was continued they would literally kill the goose that laid the golden egg, so certain of the islands were closed to mining from 1906 to 1910. During this period Coker estimates that each pair of guano birds had produced about $1.50 worth of guano per year. As these birds may be as numerous as 15,000 per acre, their value can be appreciated. On the closed islands the guano accumulated at the rate of about 4 inches per year or at the rate of 750 tons per acre per year.

Birds as Friends of Man. Birds are of importance to man in a number of different ways. Their esthetic value is great as they give much pleasure to many people, not only because of their bright colors and interesting ways but because of the beautiful songs of many of the species. In addition to their esthetic value birds are of economic importance to man because they destroy weed seeds, injurious insects, rodents and other injurious animals. Some species are also of importance because they destroy crops, domestic fowl or animals that are useful or of importance to man.

Rodent Destroyers.—The chief rodent-eating birds are included in the hawk family and the owl family, although the shrikes destroy many small rodents. Among the chief hawks that destroy small rodents or that feed very largely on rodents are the 2 species of so-called hen-hawks, the red-tailed and the red-shouldered hawk. The rough-legged hawk or black hawk feeds almost exclusively upon field mice. The marsh-hawk or white-tailed hawk feeds largely on ground squirrels and other small rodents. They seldom molest poultry as they are shy birds that shun human habitations. But as is often the case in human society where the rule is that you might as well hang a man as give him a bad name, so you might about as well shoot a bird as give it a bad name. Hence, many a hawk guilty of no more serious crime than eating an occasional rabbit and with the destruction of many rodents to his credit is shot for a hen-hawk.

The owls are universally rodent destroyers. Although they have been blamed for taking chickens and destroying game-birds, careful examinations of the regurgitated pellets of all our species show that rodents make up such a large percentage of the food of these birds that their occasional destruction of a game-bird or of a chicken roosting in a tree can be discounted. Birds should not be condemned on the basis of single acts or on the basis of single individuals of a species. Only after careful studies of the food of numerous individuals from various parts of the country can the real economic status of a bird be determined. As a general proposition our American species must be considered as highly beneficial in spite of the fact that they occasionally eat birds, as their diet consists so largely of injurious rodents. No blame should be attached to the owl that occasionally eats poultry as the blame should be placed on the careless person who leaves chickens to roost in trees at night, exposed to all kinds of marauding animals.

Weed Seed Destroyers.—The finches and sparrows and the bob-white are the principal birds that eat weed seeds. Some of the species seem to confine themselves to a few kinds of seeds. For example, the goldfinch seems to prefer the seeds of the composites like the thistle, sunflower and dandelion to the seeds of any other plants. On the other hand many sparrows are general feeders, eating the seeds of many noxious weeds. While the amount of seeds eaten by a sparrow is small, estimated by Beal as only $\frac{1}{4}$ ounce each day, the total amount of seed eaten over a large area is very great. Thus Beal estimates the amount of weed seed destroyed by the winter sparrows in Iowa, estimating the number of birds per square mile as 10 and estimating further that each bird remains for two hundred days, the total amount of weed seed eaten in Iowa during a winter would be 1,750,000 pounds or 875 tons. With these figures before us it seems safe to conclude that the sparrows are important factors in helping to keep weeds in control.

Insect Destroyers.—Birds are of more importance as insect destroyers than is ordinarily appreciated. Insects form an important part of the diet of most of the perching birds. Some birds eat insects almost exclusively both winter and summer. In this group should be placed such birds as the woodpeckers, the tits, the chickadees, the kinglets, the creepers, and the wrens. Many of our resident birds feed on insects during the summer and in addition feed their voracious developing young on the same food, while, in the winter they feed on seeds, nuts and wild fruits. In this group should be placed the bluebird, the robin, our resident thrushes, the nuthatches, our resident warblers, the resident sparrows, the meadowlark, the bob-white and others. To this list of insect destroyers must be added the host of birds that are summer residents with us or that are migrants through our territory. This list would contain many thrushes, the swallows, the gnatcatcher, many warblers, the vireos, the tanagers and others.

Birds are restless creatures and their activities demand a large amount of food to keep them going. This is especially true of the rapidly growing nestling birds. Numerous reports of careful observations on nestling birds show that nestlings devour several times their own weight in insects each day.

Birds as Enemies of Man.—The damage that birds do to crops and to poultry looms so large in the minds of people that have been damaged in this way that the bird lover feels disinclined to mention it. Some species of birds are universally destructive to man. Some species are seasonably destructive to man. While other species are only occasionally destructive. The method in the past has been to condemn all birds because a few were injurious. Thus the English sparrow is troublesome about farms and in the cities, hence, all sparrows, including our decidedly beneficial native species are to be destroyed. A bounty is offered and the head of any bird that can possibly pass for a sparrow is included. The correct method, of course, is to get the facts in the case by a careful study not only of the stomach contents of adults and fledgelings, but to study the daily feeding activities of the birds not only during the summer, but during migration and the winter also; to conduct feeding experiments to determine the range of food eaten; and lastly to study the food of the young birds in the nest to determine not only the kind of food but the amount consumed each day. Only after such a careful study as this can a real estimate of the true economic status of a bird be determined and it is only on the basis of its proven injuries that a bird should be condemned. Thus, the robin eats cherries when this fruit is ripe, but the economic status of the robin is not to be determined by its activities during this period only but by its feeding activities during the whole fifty-two weeks of the year.

On this basis only a very few of our native birds are to be condemned without qualifications. This list would include the sharp-shinned hawk, and the Cooper's hawk (the so-called blue darters) the true chicken-hawks as the majority of their food consists of poultry or other birds and only a small percentage of mice or other rodents. These are swift-flying hawks or darters not to be confused with the soaring so-called hen-hawks, which feed principally on rodents and other mammals. Thus, Fisher shows from the examination of 292 stomachs of these 2 species; that 40 or 13 per cent contained poultry or game-birds, 151 or 52 per cent other birds, 17 or 6 per cent mice, 4 or 1.5 per cent other vertebrates, 7 or 2.5 per cent insects and 98 or 34 per cent were empty. Contrast this with the results from the examinations of our five larger hawks where 1020 stomachs were examined; 64 or 6 per cent contained poultry or game, 99 or 10 per cent other birds, 492 or 49 per cent contained mice, 211 or 21 per cent other mammals, mainly rodents, 130 or 13 per cent frogs and reptiles, 184 or 18 per cent insects, 42 or 4 per cent other animals, 16 or 1.5 per cent other food and 122 or 12 per cent were empty. Or contrast it with the food of our commonest small hawk, the sparrow-hawk, where 320 stomachs were examined; one contained poultry, 52 or 16 per cent other birds, 89 or 28 per cent mice, 12 or 4 per cent other mammals, 12 or 4 per cent frogs and reptiles, 215 or 63 per cent insects, 29 or 10 per cent other animals, and 29 or 10 per cent were empty.

In the owl family the only species that should be condemned is the great horned owl and even his record is not wholly bad, for of 127 stomachs; 31 or 25 per cent contained poultry or game, 8 or 7 per cent other birds, 13 or 10 per cent mice, 65 or 50 per cent other mammals, 10 or 9 per cent insects, and 17 or 13 per cent were empty. Contrast this with the record of the other common owls representing 6 species, 639 stomachs were examined; 10 or 2 per cent contained poultry or game, 89 or 12 per cent other birds, 333 or 52 per cent, rodents, 60 or 10 per cent other mammals, 15 or 2.5 per cent reptiles and frogs, 35 or 5 per cent other animals, 126 or 14 per cent insects and 111 or 17 per cent were empty.

All other destructive birds fall in the class of seasonably destructive or occasionally destructive birds. The list of seasonably destructive birds would include a long list of common birds.

The robin's food is about one-half animal matter, chiefly insects, and one-half vegetable food; of this latter about 40 per cent was wild fruits and 8 per cent cultivated fruits but during the height of the cherry and berry season, June and July, the cultivated fruits make up 25 per cent of the food.

The catbird's food consists roughly of one-half insects and one-half fruit. The fruit is largely the small fruits like the strawberries, raspberries and blackberries which may be either cultivated or wild. Observations show that this bird is occasionally very destructive to these cultivated berries.

The grackle's food consists of one-third insects, about one-half grain, the the remainder being made up of various substances including small fruits in season. As these birds occur in great flocks and as they eat grain to such a considerable extent they may do great damage to grain fields. The examination of stomachs do not indicate that they are guilty of pulling sprouting grain or of eating the eggs of other birds to any great extent.

The red-winged blackbird's food consists of about one-fourth insects, one-half weed seed, and one-eighth grain. This bird occurs, however, in great flocks and sometimes causes widespread destruction in grain fields.

The bobolink's food in its breeding range consists chiefly of insects and weed seeds. During its migrations over the rice fields it often does great damage, pulling the sprouting rice in the spring and devouring the ripening grain in the fall.

The crow is the rascal of the bird world and seems to know it. Like most rascals he gets credit for being worse than he really is. Careful studies of the food of the crow (Fig. 49) in all parts of the country and every month in the year show that the crow's food consists of about one-fifth insects, mostly large destructive species; about one-half grain, of which sprouting corn, corn from the shock and small grains make up considerable items, but roughly one-half of all grain consumed is consumed during the winter months when the only grain available is waste grain. Cultivated fruits are eaten to a considerable extent, especially during June and July, but if all the bad things that the crow does, including pulling sprouting corn, and small grains, eating corn and small grains in the field, eating fruit and robbing birds nests of eggs and young birds are placed in the balance against the beneficial work of the crow, the beam would tip decidedly toward the beneficial. The nestlings eat such diverse elements as carrion, mice, eggs, small birds, fish, many kinds of insects and several kinds of grain, especially corn. The crow, therefore, should not be penalized too severely and wholesale destruction of crows is not advisable; although, occasional destruction may be necessary to protect a given crop.

The food of the blue jay is generally quite similar to the food of the crow. Insects and nuts form a large proportion of the jay's food, and grain and fruit a little smaller proportion. He is guilty of most of the petty crimes that have been proven against the crow, pulling sprouting grain, eating grain in the field, and destroying the eggs and nests of other birds.

In discussing all of these seasonably destructive birds it must be borne in mind that percentages given are always for the adult bird and that practically all of these birds feed their young almost exclusively on insects. The amount of food that a nestling eats can only be appreciated by a person who has attempted to rear such a bird. Kalmbach states that nestling crows require an average of 10 ounces of food per day or 13 pounds for the entire period, about three weeks,

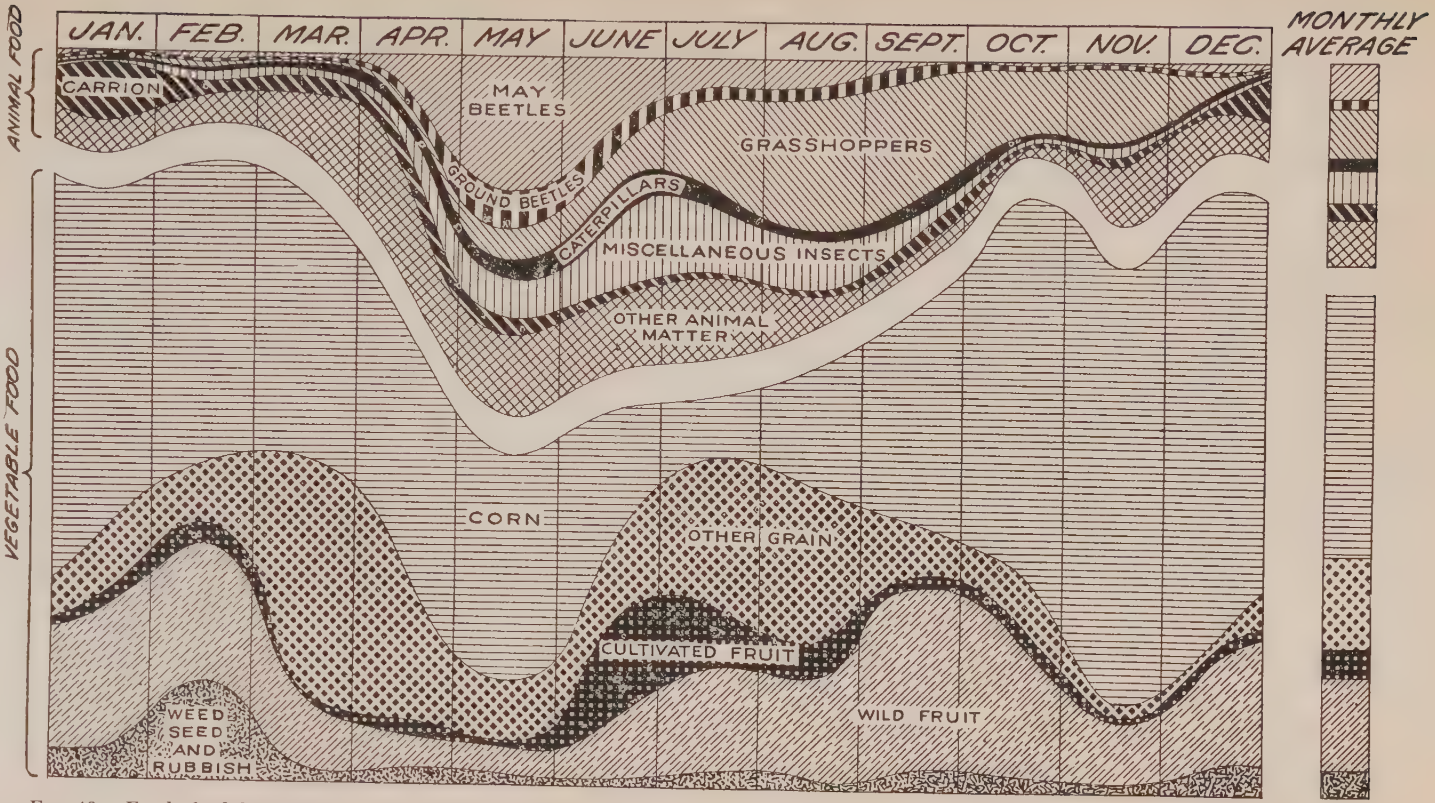


FIG. 49.—Food of adult crows. Showing the varying quantities of the principal items from month to month, and the relative monthly average of each item. (From Farmers' Bulletin No. 1102.)

spent in the nest. He records the examination of a nestling crow's stomach that had the remains of 143 grasshoppers in it.

It is hoped that this brief discussion of some of the birds that are generally considered injurious will reveal the necessity of carefully studying the food of a bird before condemning it to slaughter. And that it will help us in appreciating that there is a vast difference between the birds that are regularly destructive and those that are only occasionally or seasonably destructive.

BIRD MIGRATION.

The regular seasonal movements of birds have long been a matter of observation. In the northern hemisphere birds move northward in the spring and southward in the fall. These regular seasonal movements could not fail to attract attention and many ludicrous theories were advanced to explain these well known facts. Thus, the ancients believed that the barnacle goose came from the common barnacles belonging to the order Cirripedia (see page 180) to spend the summer and changed back to barnacles to spend the winter. The sora rail was supposed to change to a frog which buried itself in the mud during the winter to reappear as a bird the following spring. The finding of a dead swallow in the mud was sufficient evidence from which to draw the conclusion that birds buried themselves in the mud on the approach of winter only to emerge the following spring. Others believed that birds hibernated in wells, in burrows in the ground, in caves or in hollow trees. While some observers have asserted that they have seen flocks of birds plunge beneath the waves of the sea. Others believed that the smaller birds migrated on the backs of larger birds. While another explanation was that a summer resident changed into a winter resident which changed back the following spring.

While our information at the present time is practically complete as to the winter homes of our North American birds, the extent of the breeding grounds, the route taken in both the spring and autumn migrations and the approximate time that they will arrive at any given station, our knowledge of the causes of bird migrations and the factors which influence them is far from complete.

Many theories have been advanced to explain the causes of bird migrations. Some of the more important of these may be examined briefly. One of the theories advanced for bird migration is the presence or absence of food. This might have been one of the fundamental causes of bird migration originally but it cannot be considered as the only factor at the present time. Some birds leave their northern breeding grounds while food is still abundant; while some birds leave their winter quarters and push north in advance of the full development of their favorite food. On the other hand, many birds migrate much further than is necessary to find food. Thus, many birds nest in the Northern States and Canada and winter in the Gulf States. While other species which nest in the same areas continue their migrations to South America.

Another theory that has been advanced is that migrations are caused by changes of temperature. The chief objection to this theory is that migrations occur with great regularity for natural phenomena, whereas, the variations in our weather are perennial subjects for conversation. It is practically impossible to explain a constant on the basis of variables. The theory that temperature is the prime factor in migration meets a very serious objection in the fact that many birds migrate from a nesting ground in a cool temperate North American climate to a cool temperate climate in South America to spend the winter.

Still another theory is that migrations shift in the direction of the lengthening day. Thus, the birds would be afforded a much longer period for their activities. If all migrating birds were diurnal in their activities, this would be a very neat explanation but unfortunately some of our migrants are nocturnal. Then again our crepuscular birds ought to migrate to the far north where they would be furnished long periods of twilight. Another objection to this theory is that on this basis the birds that winter the farthest south should be the first to start migrating and these should be followed by regular waves of more and more northern birds. Whereas, as a matter of fact, we know there is no such regularity as this. Then too, birds which occupy the same general range should migrate at the same general time. Yet, we know that this is not true. The Canada goose for example, occupies about the same winter territory as the hermit thrush, the southeastern states generally, yet the Canada goose is usually a full month ahead of the hermit thrush in its spring migrations.

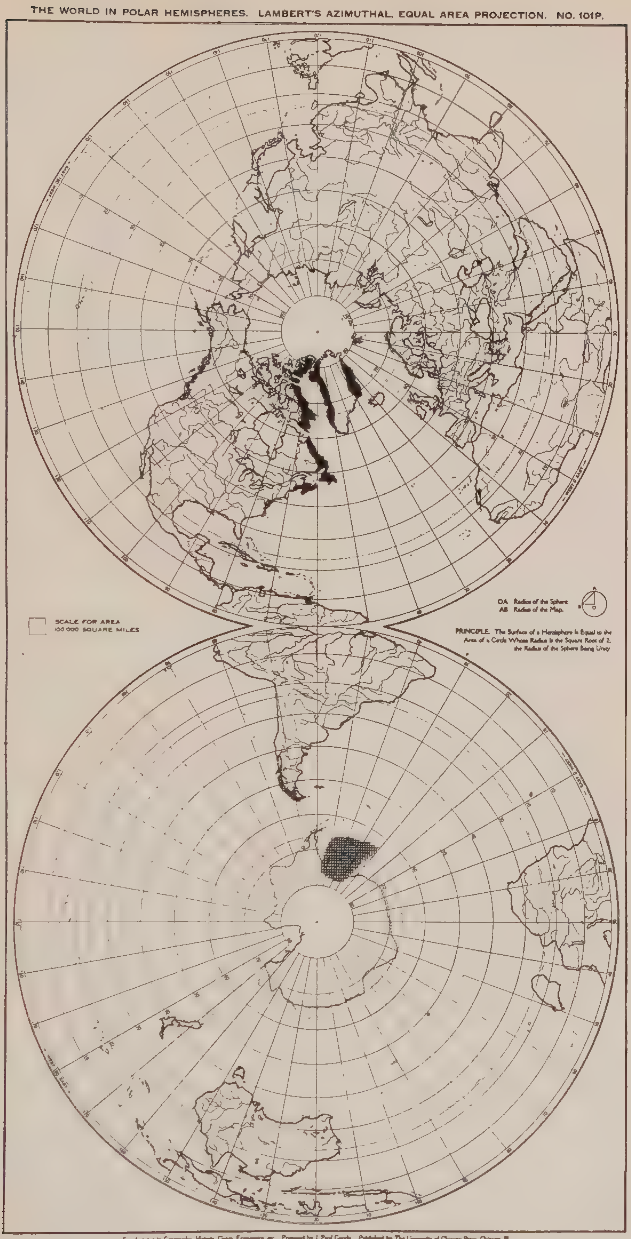
Still another theory to account for migrations is the theory that migrations are caused by the activities of hormones secreted by the gonads. Reliable students state that there are great differences in the development of the gonads in different species of birds migrating together. In some the gonads are well developed, in others poorly developed. There is likewise great variation in the nest building time of birds that may migrate together and nest in the same general region. Thus some birds start nest building on their arrival at the nesting site, while other birds loiter about their nest building. This theory also fails to explain why those birds which rear more than one brood in a season remain in the same locality and are not urged to go farther north.

Based on their migratory movements birds of any region may be classified into four groups. Residents are birds that are found in any given locality the year round. Winter residents are birds that come from farther north and spend the winter, returning to their northern breeding grounds the following spring. Summer residents are birds that come from farther south and nest in the given locality, returning to their southern abodes to spend the winter. Migrants are birds that pass through a given region going northward to nesting grounds in the spring and going south to winter quarters in the fall.

Facts of Bird Migration.—Having covered some of the theories about bird migration it might be more profitable to turn our attention to some of the facts of bird migration. These facts may be grouped under four headings: (1) distance covered by migrating birds, (2) speed of migration, (3) regularity of migration, and (4) the main migration routes.

Distances Covered by Migrating Birds.—As has been stated some birds are resident in a given locality occurring throughout the year. While this means that the species does not migrate, it does not mean that individuals do not migrate. Thus a species of bird might be resident in a given locality but the individuals that are present in the summer might go farther south to spend the winter, being replaced by more northern birds which in turn go farther north to nest being replaced by the birds from the south. However, that may be, it is believed that certain species are real residents as individuals, perhaps never wandering more than a few miles from the nest where they were hatched. The distance covered would vary, therefore, from birds that do not travel to some species like the Arctic tern (Fig. 50) that nests within the Arctic circle and winters within the Antarctic circle, a distance of nearly half way round the world, in extreme instances 11,000 miles, twice each year as this bird travels from winter home to nesting ground and back again. Other species may migrate from the far north to the southern part of South America. Many species migrate from the northern states and Canada to northern South America. While other species nesting in the same regions may be content to stop in the Gulf States or Northern Mexico. While some species may migrate from the higher mountains to the nearby lowlands.

Speed of Migration.—Most of our birds apparently make their migration flights in a rather leisurely manner. Thus Cooke estimates from numerous reports on the birds of the Mississippi Valley that they migrate at the average rate of 23 miles per day. Speed of migration is apparently dependent upon the distance traveled, being much faster for birds that travel great distances. Thus the gray-cheeked thrush travels nearly 4000 miles in a month from the time it reaches the southern states until it reaches its farthest north in Alaska. The Arctic tern spends about three and a half months on its nesting grounds in the Arctic circle, about the



THE WORLD IN POLAR HEMISPHERES. LAMBERT'S AZIMUTHAL, EQUAL AREA PROJECTION. NO. 101P.
SCALE FOR AREA
100,000 SQUARE MILES
OA Radius of the Sphere
AB Radius of the Map.
A
B
O
PRINCIPLE. The Surface of a Hemisphere Is Equal to the Area of a Circle Whose Radius Is the Square Root of 2, the Radius of the Sphere Being Unity
WEST 0 EAST

For class use in Geography, History, Civics, Economics, etc. Prepared by J. Paul Goode. Published by The University of Chicago Press, Chicago, Ill.
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FIG. 50.—Migration of the Arctic tern. The solid portions indicate the summer range while the cross-hatched areas show the winter range.

same time in its winter quarters within the Antarctic circle and has only about five months to make a round trip journey of some 22,000 miles or nearly 150 miles per day.

Regularity of Migrations.—One of the astounding things about bird migrations is the clock-like regularity with which the same species shows up at a given station year after year. Thus of 50 spring migrants observed by Brimley, the earliest date recorded for these species averaged only nine days earlier than the average dates for the arrival of these species. This is a remarkable regularity when it is remembered that most of these species had to travel hundreds and even thousands of miles to arrive at this station. This is simply another way of saying that if careful records are kept over a series of years that it is possible to predict within a week the time of the arrival of any bird.

Associated with this great regularity is another phenomenon of great interest and that is the fact that the same bird may return to the same locality even the same yard to nest year after year. By placing a small metal band bearing a serial number on the legs of birds and then trapping them it has been possible to learn much about the movements of individual birds.

The Main Migration Routes.—The careful records of numerous bird students year after year in hundreds of different localities in North America have revealed the routes taken by birds in their migrations. These records have been summarized by Cooke. Migration routes must be looked upon as great waves which originate in the winter home of the bird and beat ever northward to break upon the shores of their breeding grounds. Some of these waves are narrow like those of some of our shore birds which migrate only along the ocean front, others are broad and may occupy the entire area of the great Mississippi Valley or all the territory between the Atlantic Ocean and the Rocky Mountains.

Careful study of these migration routes reveals many interesting facts. Some of these may be listed as follows: (1) Birds occupying the same general breeding range do not necessarily spend the winter in the same region. (2) Birds occupying the same winter region do not necessarily occupy the same breeding range. (3) Birds occupying the same breeding range and the same winter region do not necessarily travel the same migration routes. (4) Birds do not necessarily travel the same routes in the fall migration to the winter home that they traveled in the spring migration to the breeding range. (5) Some birds of the same species from the same breeding range migrate to the Atlantic and some to the Pacific Coast.

As an example of the first of these statements (Fig. 51), the vesper sparrow, the bobolink, the scarlet tanager, the black-throated blue warbler, and the magnolia warbler breed in the Northern States and Canada. Yet, the vesper sparrow migrates only to the South Atlantic States; the magnolia warbler to Central America; the black-throated blue warbler to northern South America; the scarlet tanager to Peru; and the bobolink to Patagonia.

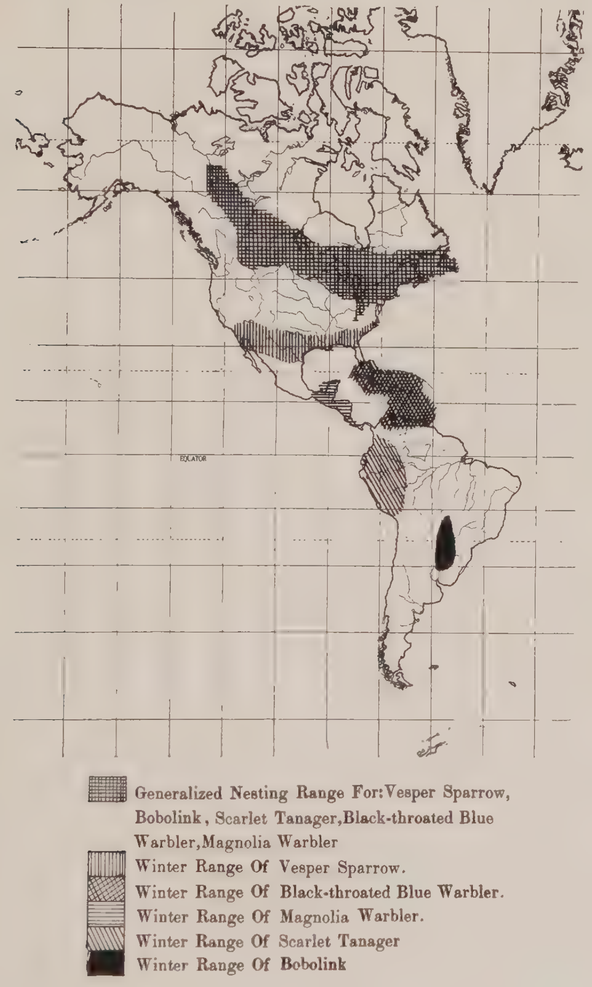

EQUATOR
Generalized Nesting Range For: Vesper Sparrow, Bobolink, Scarlet Tanager, Black-throated Blue Warbler, Magnolia Warbler
Winter Range Of Vesper Sparrow.
Winter Range Of Black-throated Blue Warbler.
Winter Range Of Magnolia Warbler.
Winter Range Of Scarlet Tanager
Winter Range Of Bobolink

FIG. 51.—Winter and summer ranges of the vesper sparrow, bobolink, scarlet tanager, black-throated blue warbler and magnolia warbler.

As an illustration of the second statement, the golden plover (Fig. 52) and the bobolink occupy the same general winter range in South America, Patagonia. Yet, the breeding range of the former is the extreme northern part of North America within the Arctic Circle; of the latter, the Northern States and Southern Canada.

Many birds occupying the same breeding range do live together in the winter. Thus, many of the birds that nest in the Northern States and Southern Canada spend the winter together in northern South America. Familiar examples are most of the swallows, and many of the thrushes, and warblers.

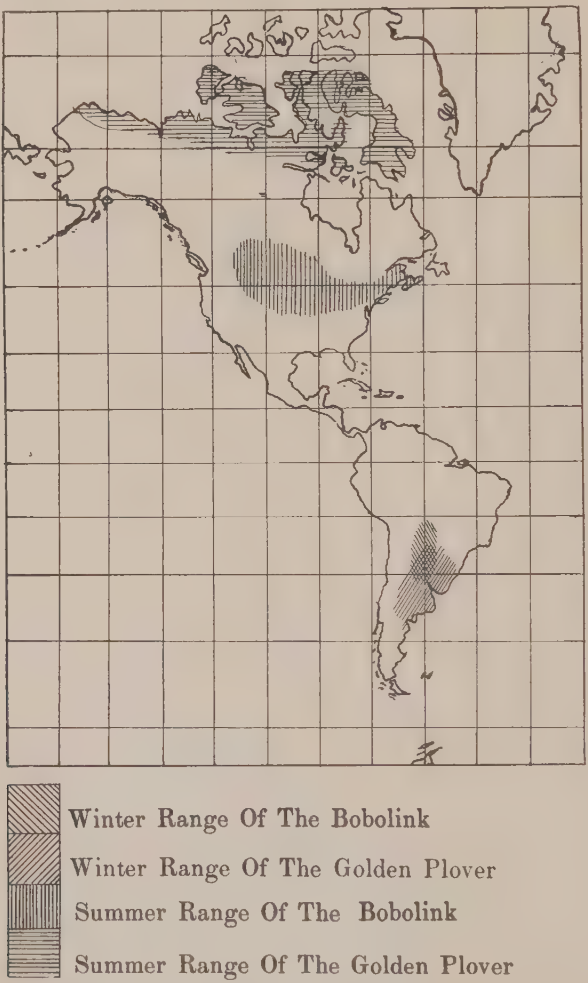

Winter Range Of The Bobolink
Winter Range Of The Golden Plover
Summer Range Of The Bobolink
Summer Range Of The Golden Plover

Fig. 52.—Winter and summer ranges of the bobolink and golden plover.

As an illustration of the third statement, the cliff swallow and the black poll warbler both winter in northern South America, and breed in North America ranging to Alaska, the Arctic Ocean and Labrador. Yet, the cliff swallow migrates around the Gulf of Mexico by way of Central America and Mexico, while the black poll warbler migrates across the Carribean Sea by way of Cuba and Florida.

As an illustration of the fourth statement, the golden plover winters in Patagonia and nests on the shores of the Arctic Ocean. In the spring migration it flies across South America to Central America to Yucatan then across the Gulf to the United States and directly to its breeding grounds. On its return in the fall it follows the coast of Labrador to Nova Scotia, then directly across the Atlantic to northern South America.

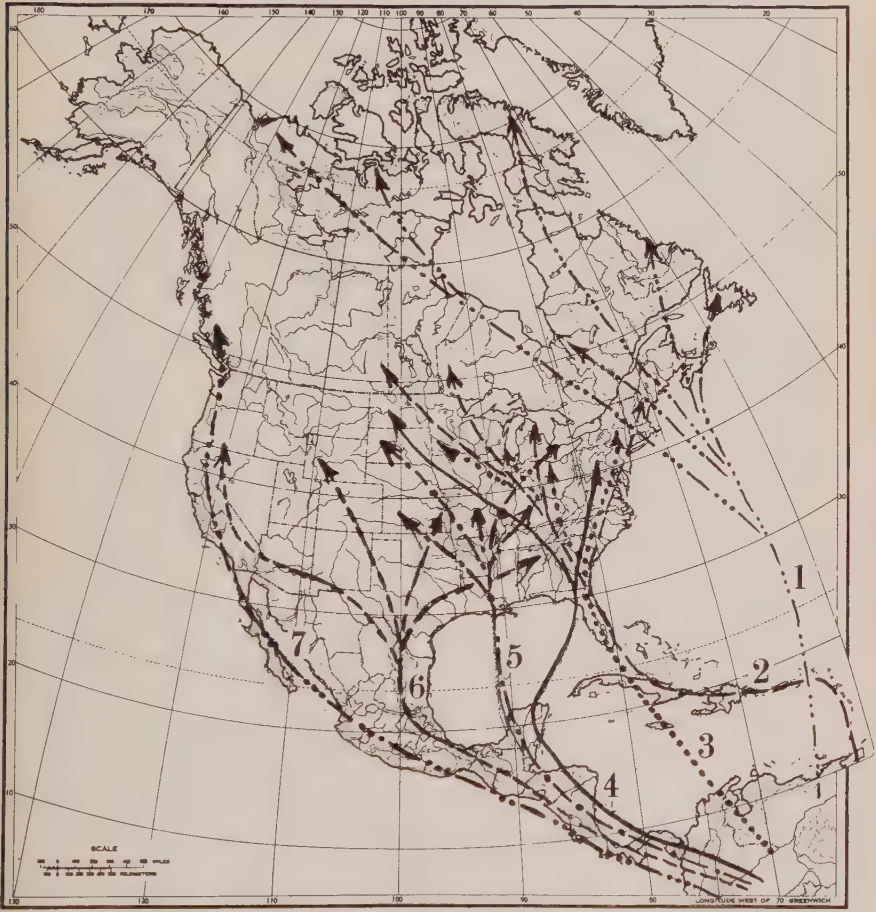


FIG. 53.—Migration routes of common North American birds.

As an illustration of the fifth, Cooke cites the white-winged scoter which nests in the interior of Canada from the northern boundary of the United States to the Arctic Ocean. Yet, some of the birds migrate westward to the Pacific to spend the winter along the Pacific Coast of the United States. While other birds migrate eastward to

Labrador and then south to spend the winter along the Atlantic Coast from the New England States to North Carolina.

The chief migration routes (Fig. 53) from northern South America are: (1) Directly from northern South America to Nova Scotia and New England and thence to Labrador, the Hudson Bay, and the Arctic coast. (2) From northern South America by the Lesser Antilles, the Greater Antilles to Florida and then coastwise to the North Atlantic States, New England, and Quebec; or to the interior west of the Alleghanies to the North Central States. (3) From northern South America by way of Jamaica, and Cuba to Florida where this route coincides with the branches of route 2. (4) From northern South America through Central America to Yucatan across the Gulf to Florida where this route coincides with the branches of route 2. (5) From northern South America across Central America to Yucatan then across the Gulf and up the Mississippi Valley to the Great Plains States, the interior of Canada or Alaska. (6) From northern South America across Central America and Mexico with three branches, one eastward to the Mississippi Valley, another to the Rocky Mountain region and a third to the Pacific Coast States. (7) From northern South America coastwise along Central America, Mexico, and Lower California to the Pacific States and Canada.

Some of the birds that winter in North America follow the same routes, especially from the Gulf States and Mexico by routes 2, 5 and 6. Others follow different short routes. Thus the great migration of ducks and geese from the Chesapeake Bay, Potomac River, North Carolina Sound regions is up the Potomac, across the mountains, up the Great Lakes, to the interior of Canada.

Having considered briefly the routes taken during migrations, the regularity of migration and the precision with which birds return to the same breeding range and back again to their winter home, the question naturally arises how the birds find the way back to the same route or back to the same range or winter home. And when we remember that many marked birds have been recaptured year after year in the same locality our amazement knows no bounds. This is one of the unanswered questions in biology. To say that the birds have a special sense of direction only answers the question in part for when we commence to search for the stimuli which would excite this sense of direction we get into deep water. For birds of different species migrate with apparently equal facility by day or by night; the larger birds quite generally by day, and the smaller birds by night; in cloudy, rainy, or snowy weather or in heavy fog as easily as on bright clear days or nights. Thus we would seem to eliminate the sun, the stars, familiar landscape marks and other stimuli dependent on sight. While storms often carry birds far out of their usual routes, birds otherwise seem to migrate independently of the wind.

So we leave this question with the statement that birds have a special sense of direction, highly developed certainly in such birds as the homing pigeon, without any clear understanding of the factors involved.

THE NESTING HABITS OF BIRDS.

With the single exception of the cowbird, all our North American birds construct some sort of nest in which they lay their eggs and incubate them until they hatch. The cowbird lays its eggs in other birds' nests and leaves the incubation and the care of the young to the foster parents. Birds' nests are generally composed of characteristic materials and usually placed in typical locations so that as a general rule the bird student can determine the builder from the type of nest that is built. As a general rule the material from which the nest is built comes from the locality where the bird spends most of its time. Thus the marsh-loving birds like the black tern, the bitterns, blackbirds, rails and marsh wrens make their nests of rather closely woven grasses, reeds and cattail leaves. The ground-loving birds usually make theirs of leaves and grasses. In the ducks and geese these nests are lined with down from the mothers' breast but in other ground-loving birds like the woodcock, the ruffed grouse, and the wild turkey the nests are simply lined with leaves. The bob-white, ovenbird, and meadow-lark make their nest chiefly of grasses which are often brought together over the nest to form a cover. Many of our land birds build their nests of grasses, plant fibers, strips of bark, twigs, or rootlets and line them with fine grasses, feathers, plant down or hair. Some birds transport material for a considerable distance. The swallows make their nests by cementing pellets of mud together. The chimney swift makes its nest out of small twigs glued together with the glue-like saliva. The robin and the wood-thrush line their nests with mud.

The nesting habits of many birds have changed with the changes brought by civilization, thus some birds which formerly nested in natural cavities, or woodpecker holes now nest about buildings or in bird houses. Thus, the chimney swift which formerly nested in hollow trees now nests almost exclusively in chimneys. The bluebird, the house wren and others prefer to nest in a bird house but will nest in natural cavities if bird houses are not provided.

To help make clear the various nesting habits of birds the following diagram (Fig. 54) has been constructed of typical locations of the nests of some North American birds. It is believed that most of the usual nesting situations have been included. The names of the most typical bird occupying these situations have been placed beneath as a guide. Assuming that formerly all birds nested on the ground, lines have been drawn from these different habitats to indicate how birds might have changed their nesting habits from one location to another. If birds are known which nest indifferently in one or the other of two situations the line connecting these two situations is solid and the name of a bird that has this habit of nesting indifferently in two situations is inserted.

If there is an obvious connection between two situations but no bird is known which nests indifferently in the one or the other a dotted line is used to connect these two situations. Thus, the wood-duck nests in natural cavities, and the solitary sandpipers in abandoned nests. The saw-whet owl nests in natural cavities or in abandoned nests as circumstances seem to warrant. On the other hand the cowbird imposes on other birds. Now it seems quite logical that a bird that acquired the habit of laying in abandoned nests might occasionally lay its eggs in nests that were occupied and might eventually do the one or the other indifferently and might eventually acquire the habit of imposing on other birds exclusively,

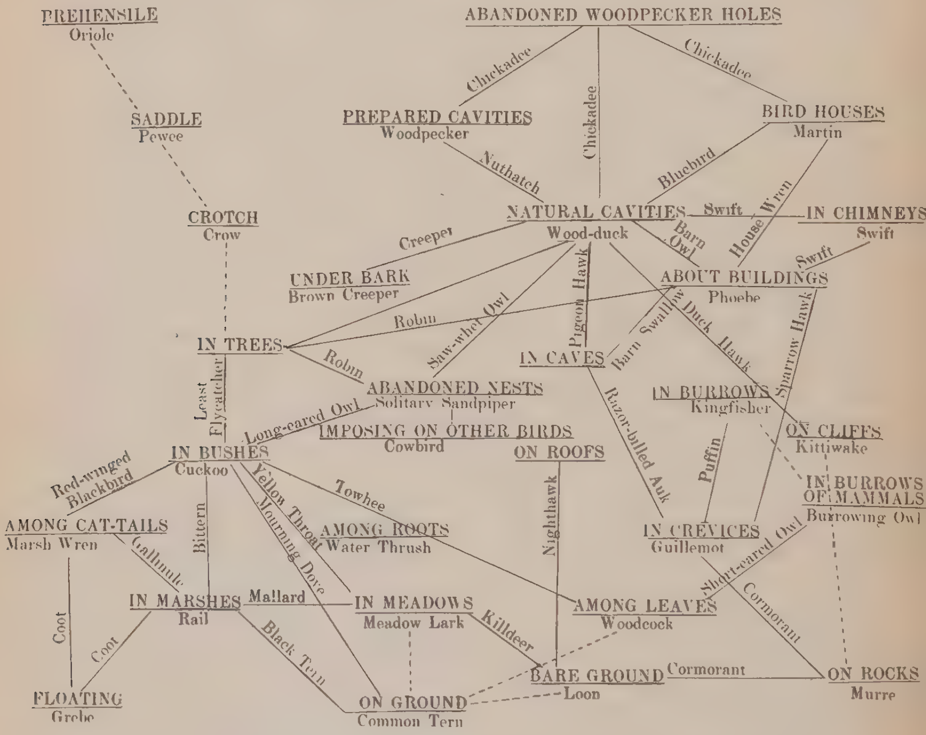

PREHENSILE
Oriole
ABANDONED WOODPECKER HOLES
Chickadee
Chickadee
Chickadee
SADDLE
Pewee
PREPARED CAVITIES
Woodpecker
BIRD HOUSES
Martin
Nuthatch
Bluebird
House Wren
CROTCH
Crow
NATURAL CAVITIES
Wood-duck
Swift
IN CHIMNEYS
Swift
Barn Owl
Creeper
Swift
UNDER BARK
Brown Creeper
Pigeon Hawk
ABOUT BUILDINGS
Phoebe
Robin
Saw-whet Owl
Barn Swallow
Duck Hawk
Sparrow Hawk
IN TREES
Robin
IN CAVES
Least Flycatcher
ABANDONED NESTS
Solitary Sandpiper
Razor-billed Auk
IN BURROWS
Kingfisher
Long-eared Owl
IMPOSING ON OTHER BIRDS
Cowbird
ON ROOFS
ON CLIFFS
Kittiwake
IN BUSHES
Cuckoo
Red-winged Blackbird
Yellow Throat
Towhee
Puffin
IN BURROWS OF MAMMALS
Burrowing Owl
Mourning Dove
Nighthawk
AMONG CAT-TAILS
Marsh Wren
Bittern
AMONG ROOTS
Water Thrush
IN CREVICES
Guillemot
Short-eared Owl
Gallinule
Cormorant
IN MARSHES
Rail
Mallard
IN MEADOWS
Meadow Lark
AMONG LEAVES
Woodcock
Coot
Killdeer
Coot
Black Tern
BARE GROUND
Cormorant
ON ROCKS
Murre
FLOATING
Grebe
ON GROUND
Common Tern
Loon

Fig. 54.—A diagram of the typical nesting habits of North American birds.

but no bird is known which nests thus indifferently. Hence, the line connecting these two habitats is a dotted line.

In the same way any other nesting habit might be analyzed with the aid of the diagram and some understanding of the way a particular nesting habit has arisen might be determined.

SONGS OF BIRDS.

Some of the most interesting habits of birds are associated with courtship, nest building and the rearing of the young. Associated with the courtship of birds are many interesting customs, strange dances, strutting, peculiar flights; and in the land birds the great development of the vocal organs and singing.

Bird songs and call notes are usually distinctive and the student of birds soon learns to distinguish birds as readily by sound as he does by sight. A bird song may be defined as composed of several notes or syllables, whereas a call note is composed of only a few syllables. Birds may sing while on the wing, or while seated on a perch, or while engaged in their daily activities of nest building or feeding.

The song of flight while the bird is on the wing is perhaps best illustrated by the European skylark, but it is indulged in by several of our American birds notably the horned lark, the bobolink, the purple finch, the goldfinch, the kinglets and others. Birds singing the flight song seem to be so full of their efforts that they are literally carried upward on the wings of song.

Some birds seem to select a perch high in a tree overlooking their domain and sing regularly from this outlook. The cardinal, the brown thrasher and the mocking-bird have this habit.

Other birds seem to sing continuously without regard to their other activities. Such birds as the vireos, the Maryland yellow throat, and others sing while searching for food or bringing material for the nest, perhaps, pausing only long enough to finish the song and then going on with their work.

The song period of birds varies a great deal. All birds are at their best during the period of courtship, nest building and the incubation of the eggs. Most birds only sing at that time but a few like the cardinal, and the Carolina wren sing practically all the year round.

It is very difficult to classify and describe the songs of birds. No attempt shall be made to describe bird songs. A few of the outstanding types of birds' songs taken only from common Eastern North American species will be listed in the hope that the student will make an effort to study this interesting habit in the field and become familiar with the song and the singer.

The first group includes songs that may be described as thin, wiry, high-pitched, or insect-like. Typical examples are many of the warblers such as the black and white creeping warbler, the grasshopper sparrow, the savanna sparrow, and the golden-crowned kinglet.

Of a somewhat similar nature are the monotonous chipping songs of such birds as the chipping sparrow, the pine warbler, and the junco which are so largely a repetition of the same note. Close to these would come the monotonously reiterated songs of the vireos, which are composed of different notes. Likewise the trilling songs of such birds as the white-throated sparrow, the field sparrow and the like are composed of a few notes often running into long trills. The chanting songs of such birds as the song-sparrow and the vesper sparrow are more elaborate renderings of the same theme. The song-sparrow has perhaps fifteen or twenty different songs but all recognized as variations of the songs of one bird.

Of slightly different character are the thin high-pitched canary-like songs of such birds as the goldfinch and the tree sparrow. Related to the songs of this type are the warbling songs which are fuller and more varied. Songs of the warbling type are sung by many of our North American birds such as the purple finch, the house wren, the warbling vireo, the indigo bunting, the ruby-crowned kinglets, the winter wren, and the bluebird.

Closely related to these are the rollicking songs of the robin, the orioles, the tanagers, and the rose-breasted grosbeak; all songs of the same general character and frequently mistaken for each other. These songs are full, powerful, and partake of the monotony of the songs of the vireos. They differ, however, in being freer and fuller of the joy of life.

The bubbling songs of the bobolink bear somewhat the same relation to the warbling songs that the rollicking songs bear to the monotonous reiterated songs. The bubbling songs are rich and full of liquid notes.

The liquid songs of the towhee and the red-winged blackbird and the flute-like vesper songs of the wood-thrush and hermit thrush have much in common. They are noted for their beautiful liquid-like qualities, and they are composed of relatively few notes, repeated over and over like the reiterated songs. These songs are justly rated as among the most beautiful songs of our North American birds.

The whistling songs of the cardinal, Carolina wren, tufted titmouse, ovenbird, and Kentucky warbler have one thing in common with the chippy-like songs. They are both composed of similar notes repeated over and over. The whistling songs, however, are much louder and constitute one of the dominant elements in bird music. The song of the same bird is often quite varied, but the same timbre runs through all the varied songs of a species and once learned will always be recognized.

The mimicking songs of the mocking-bird, brown thrasher, catbird, and chat are of entirely different character and contain notes suggestive of the songs of other birds, all brought together to make songs that are among the most pleasing in the bird world. However, it is not clear whether these birds are mocking other birds or simply singing their own songs which resemble other birds songs in part.

Call notes are usually distinctive for the species but within the species there is much variation in the call notes under different circumstances, thus the call of the contented well-fed bird as it goes to roost at night is quite different from the call of the same bird surprised by an enemy. Call notes have been developed to the greatest extent in the crow which seems to have a whole series, each one suited to the occasion, one for general alarm warning of the approach of enemies, one indicating the presence of food, one that signifies that all is well, a call to play and the like.

This brief review of some of the more common types of bird songs should stimulate the student to a more careful study of the songs of birds in their native haunts. And this in turn should serve as an introduction to the study of the habits and lives of birds. Such a study of birds will enrich the lives of everyone and give him an understanding of Mother Nature's children which cannot be acquired in any other way.

CHAPTER III.

THE REPTILIA.

- Definition
- Classification:
  - Chelonia
    - Their chief value to man
  - Lacertilia
  - Ophidia
    - Poisonous snakes
    - How-poisonous snakes bite.
      - Remedies
    - Non-poisonous snakes
  - Crocodilia
    - Uses to man
- Some Popular Superstitions about Reptiles

The reptilia include the turtles, lizards, snakes and alligators. While the external form is somewhat diverse the reptiles have many characters in common. The more obvious of these characters (Fig. 55) may be listed as follows:

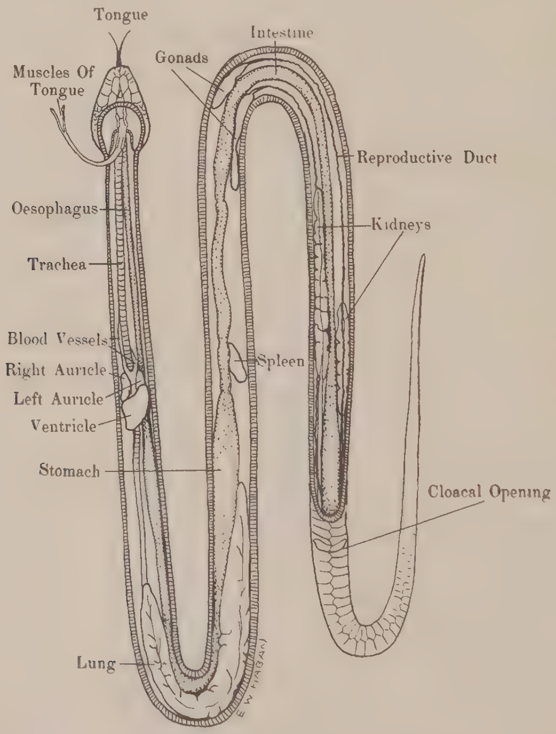

Tongue
Intestine
Gonads
Muscles Of Tongue
Reproductive Duct
Oesophagus
Kidneys
Trachea
Blood Vessels
Right Auricle
Spleen
Left Auricle
Ventricle
Stomach
Cloacal Opening
Lung
E W HAGAN

Fig. 55.—Diagram showing the general internal structure of a reptile.

1. The body is covered with bony plates or scales.
2. All the members of this class are cold-blooded, *i. e.*, the temperature of the body varies with the temperature of the surrounding medium.

3. All reptiles breathe by means of lungs. This applies to the terrestrial, amphibious and aquatic species.

4. All reptiles lay eggs or retain the eggs within the body until they hatch. The eggs are never laid in the water but are laid on land even in the strictly aquatic species.

5. Fertilization is always internal.

6. After hatching the young resemble the adults and do not go through a metamorphosis.

7. Most of the reptilia have two pairs of legs, absent in some lizards and in all snakes.

8. The heart is four-chambered with the ventricle completely or partially divided.

9. Both the right and left aortic arches are functional.

CLASSIFICATION.

For our purposes it seems better to divide the class reptilia into four orders: *Chelonia* (Testudinata) the turtles, terrapins and tortoises, *Ophidia* (Serpentes) snakes, *Lacertilia*, lizards and *Crocodilia*, the crocodiles and alligators. This classification includes only the modern North American forms. Fossil forms are numerous and would extend this list to about twenty-four orders.

The only living reptile that would not fall in the above orders is the Sphenoden of New Zealand, which is a large reptile resembling a lizard about 2 feet long with a series of spines from the top of the head to the end of the tail. While this reptile resembles a lizard in external form it possesses many primitive characters of interest to the zoölogist.

Class Reptilia.

Order: Chelonia		
Family Kinosternidæ		Musk and mud turtles.
Family Testudinidæ		Pond and land turtles.
Family Chelydridæ		Snapping turtles.
Family Trionychidæ		Soft-shell turtles.
Family Dermochelyidæ		Leather back turtles.
Family Cheloniidæ		Marine turtles.
Order: Lacertilia		
Family Iguanidæ		Swifts.
Family Anguidæ		Glass lizards.
Family Helodermatidæ		Bead lizards.
Family Teiidæ		Race runners.
Family Scincidæ		Skinks.
Order: Ophidia		
Family Boidæ		Boas.
Family Colubridæ		Common snakes.
Series Aglypha	Non-poisonous	Colubrids.
Series Opisthoglypha	Poisonous	Colubrids.
Family Elapidæ		Cobras.
Family Viparidæ		Old World vipers.
Family Crotalidæ		New World vipers.
Order: Crocodilia		
Family Crocodilidæ		Alligators.

Some zoölogists would unite two of our orders, the *Lacertilia* and the *Ophidia* into a single order, the *Squamata*. While this classification has much merit from a purely structural standpoint; the habits of the lizards and snakes are so different and with the exception of a few forms they can be so readily distinguished, by the presence of legs in practically all lizards and their complete abscence in all snakes; that it seems much better to separate them as two distinct orders. The outline of classification (page 115) will aid the student in placing our conspicuous North American reptiles and will help him to understand the relations of the various forms.

A BRIEF DISCUSSION OF SOME OF THE MORE INTERESTING REPTILES.

In the following discussion only a few of the more interesting reptiles can be discussed and for the most part our illustrations will be drawn from North American forms with only incidental mention of a few forms from other parts of the world.

Order Chelonia.—This order includes the turtles, terrapins and tortoises. These three common names are used indiscriminately for different species of land, fresh-water, brackish-water, and marine chelonians. The turtles are readily separated from the other reptiles. All forms have a flattened oval or circular shell composed of bony or horny plates firmly united to the axial skeleton. The shell is divided into the dorsal carapace and the ventral plastron. The carapace is firmly anchored to the ribs and the plastron is usually united to the carapace by a bridge on each side of the body. The pectoral and pelvic girdles are free. The pectoral girdle lies inside of the ribs and not externally as it does in the other vertebrates. Two pairs of limbs are always present. The neck is elongate and the head is flattened and triangular in outline. The jaws are powerful without teeth but with sharp cutting edges. The tail is elongate. The shell is usually ample so that the head, limbs and tail may be withdrawn for protection. The skin of the head, neck, limbs and tail is covered with scales.

Family Kinosternidæ.—This family includes the musk turtles and the mud turtle, *Kinosternon odoratum*. These are aquatic turtles with strong musky odors. Our species are all small with the shell usually less than 4 inches long and quite deep. The plastron is usually large and hinged so that it can be more or less completely closed. The feet are webbed. Seven species are recognized in the United States. All of them live in ponds and sluggish streams.

Family Testudinidæ.—This family includes the pond turtles, the wood turtles, the box turtle, the diamond-back terrapin, the painted turtles, the sliders and the gopher turtles. This is the largest family of North American turtles. About 30 species are known from the

United States alone. They live on the land, in ponds and streams, and in salt marshes. The shell is rather flat, deeper in the land turtles. The carapace is ovate with the edges usually flaring, the plates of the carapace are distinct, usually beautifully ornamented or colored.

The name pond turtle may be used to cover a number of different species of turtles with rather flat shells that live in ponds and sluggish streams. They come out on the bank, or on rocks or logs to sun themselves and slide off into the water when disturbed, hence the name sliders. Most of our species are from 6 to 10 or 12 inches long and many of them are used for food.

The box turtles, *Terrapene spp.*, have a thick convex shell with the plastron hinged so that the shell may be completely closed. These are small turtles about 6 inches long. They are strictly terrestrial in their habits. The box turtles range from Maine to Mexico, and are fairly common throughout the Southeastern United States.

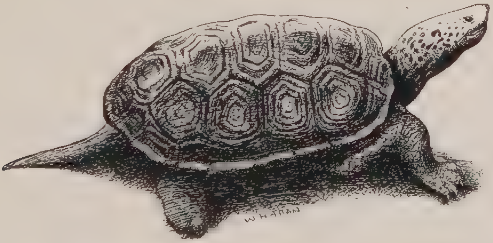


FIG. 56.—Diamond-back terrapin. *Malaclemys centrata.*

The diamond-back terrapin, *Malaclemys centrata* (Fig. 56), is the most famous of the food turtles. The diamond back is a small turtle about 7 inches long. Each plate is ornamented with concentric lines. This turtle lives in the salt marshes. Formerly common along the Atlantic and Gulf Coasts it has been so extensively hunted that it has completely disappeared from most of this area. Formerly so common that there is said to be a law in Maryland prohibiting the feeding of slaves on terrapin more than three times a week, the diamond-back became a choice of the gormand. The demand increased, the price rose steadily from a few dollars a dozen to $75.00 or a $100.00 a dozen and the animal's fate was sealed. More recently the Bureau of Fisheries has been conducting experiments which show that the terrapin will lay its eggs in confinement, that these eggs can be hatched and the young raised until they are able to shift for themselves. In this way it is hoped that extensive areas of salt marshes not suited for any other purpose may be restocked with this valuable food animal.

The gopher turtles, *Gopherus spp.*, are terrestrial turtles found in the South Atlantic, Gulf and Southwestern States. They live in sandy areas and dig burrows in the ground for several feet. The turtles live in these burrows coming out to feed after rains or early in the morning. They feed entirely on vegetable matter.

Family Chelydridæ.—This family includes only the snapping turtles (Fig. 57). Three species are recognized in the United States, the common snapper, *Chelydra serpentina,* which occurs all over the United States east of the Rocky Mountains, the Florida snapper of Florida, *Chelydra osceola,* and the alligator snapper, *Macrochelys temmincki,* of the Gulf States. These are the largest of the fresh water turtles. The common snapper may reach a length of 12 to 15 inches and a weight of 30 to 50 pounds. The alligator snapper is larger, 18 to 26 inches with a weight of 100 to 125 pounds. These turtles are strictly aquatic. Their jaws are very powerful and hooked at the tip. These turtles are voracious feeders, eating fish and water birds. The eggs are laid near the water in a bank and according to Agassiz a clutch consists of from 24 to 48 rounded eggs. The snappers are highly valued for food.

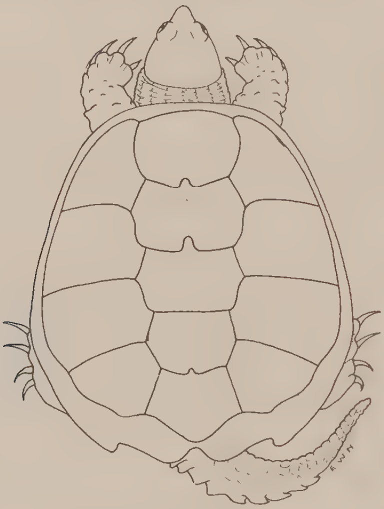


FIG. 57.—Snapping turtle. *Chelydra serpentina.*

Family Trionychidæ.—The soft-shelled turtles live in streams and ponds. The shell is soft and leathery, of one piece and not hard and horny and divided into separate plates as in the other fresh-water turtles. The shell is nearly circular in outline and very flat. The neck is long and the feet are webbed. The head is produced into an elongate snout. They are voracious feeders, eating fish, crustaceans, mollusks, and other aquatic animals. They are sometimes caught on the hook and line of the fresh-water fisherman and are prized for food. The flesh is said to be especially delicately flavored.

Family Dermochelyidæ.—This family includes the marine leatherback turtle, *Dermochelys coriacea.* This is a very large turtle reaching a length of 6 feet or more, and a weight of 1000 pounds or more. The carapace consists of a leathery shield with seven longitudinal ridges. The legs are reduced to flippers without evident toes. The forelegs are as long as the body. It is an inhabitant of the warm or tropic oceans often wandering up the Atlantic Coast as far as the New England States.

Family Cheloniidæ.—This is a family of marine turtles of large or very large size. The legs are paddles and the forelegs are very much larger than the hindlegs. The plastron is weak and poorly developed. This family contains the green turtle, the tortoise-shell turtle and the loggerhead turtle.

The green turtle or edible sea turtle, *Chelonia mydas,* as it is called, is a large turtle reaching a length of nearly 4 feet and a weight of 500 pounds. It is fairly common and is much esteemed for food. The turtles sent to market are usually small, weighing 25 to 50 pounds. The flesh is delicate and the fat is green in color. Turtles are captured for market in various ways. Some are taken as they crawl up on the sand to lay their eggs. Some are harpooned as they lie basking in the sun on the surface of the ocean. Some are captured on their feeding grounds. Some are taken in nets. In some regions the natives are said to capture them in water along shore where the turtles congregate on the bottom of the ocean. The green turtle lays its eggs on sandy beaches above high tide. A shallow hole is dug in the sand and the eggs laid and then so neatly covered that it is often difficult to find the place where the eggs were laid. A clutch is said to consist of from 75 to 150 eggs. These eggs are prized as food. The white or albumen does not coagulate and only the yolks are used for food. The young hatch in about two months and take to the sea where they shift for themselves.

The tortoise-shell turtle, *Eretmochelys imbricata,* is smaller than the green turtle, about 3 feet long in the larger specimens. Its carapace yields the genuine tortoise shell which was formerly prized for such ornaments as combs, the backs of hair brushes and similar articles. The genuine article is very beautiful but an imitation has been placed on the market which has the virtue of being much cheaper, hence the genuine article is no longer in demand.

The loggerhead turtle, *Caretta caretta,* is one of the large marine turtles reaching a length of 3 feet or more and a weight of 300 pounds or more. Both the eggs and flesh are used for food but the flesh is not considered of as fine flavor as the flesh of the green turtle.

The Chief Value of Turtles to Man.—Turtles are chiefly of value to man as food. The flesh and the eggs of turtles furnish a pleasing variation, especially in the diet of fisher folks, but for the rest of mankind turtle soup is merely an incidental tidbit. If we ranked the turtles according to the esteem in which they are held by epicureans they would rank about as follows: the diamond-back terrapin first, followed closely by the green turtles, and the snapping turtles, the loggerhead turtles, the sliders, and the soft-shelled turtles would rank in order. Tastes in foods, however, are largely a matter of style or popular fancy as it is very doubtful if there is much difference in the various species. The writer cannot pose as an expert but although he has eaten turtle soup made from all these species except the soft-shelled turtles and sliders he has never been able to notice the vast superiority of the diamond-back over the others.

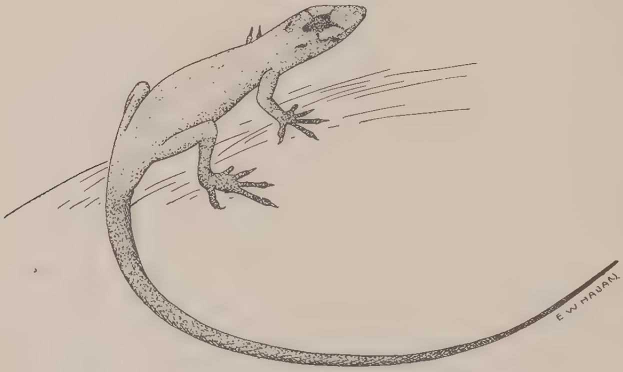


FIG. 58.—American chameleon. *Anolis carolinensis.*

Order Lacertilia.—The lizards all have a characteristic appearance. The entire body is covered with scales. The head is broad and flat, the mouth is large, the eyes small with moveable eyelids, and the external ear opening usually evident. The neck is short. The body and tail are generally elongate and the latter is usually tapering. Two pairs of limbs are generally present, although some of our lizards are legless.

Family Iguanidæ.—This family contains the swifts, the American chameleon, the horned toads, the fence lizard, the collared lizard, the chuck-walla, the spotted lizards, and some others. This family also contains large tropical iguanas, often reaching a length of several feet. They feed chiefly on leaves and fruit and their flesh is used for food and is said to have a fine delicate flavor. The iguanas occur chiefly in the West Indies, Central America and Mexico.

The swifts are characteristic of the Southwestern United States in the great semi-arid region. They are small lizards usually from 6 to 10 inches long, dull colored, and with the tail longer than the body. They move very rapidly over the rocks, hence the common name swifts.

The American chameleon, *Anolis carolinensis* (Fig. 58), is a slender lizard about 5 to 7 inches long. It is remarkable for its color changes which range from yellowish-gray, to green, to brown, to black, depending upon its surroundings and the temperature. The males are provided with a throat fan which may be distended when the animal becomes excited. These lizards live in trees and bushes and feed on insects, which they stalk as a cat stalks a bird. These lizards are abundant along the Atlantic and Gulf coasts from North Carolina to Mexico. They are often sold to tourists as pets.

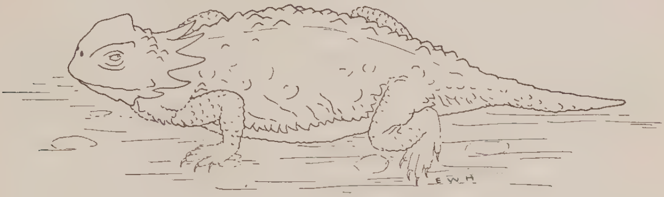


Fig. 59.—Horned toad. *Phrynosoma spp.*

The horned toads, *Phrynosoma spp.* (Fig. 59), belong to the Southwest and to the desert areas or our country. They are, of course, not toads at all but short-tailed, flattened, broadly oval lizards with the back of the head fringed with long pointed scales. They feed on insects and are active while the sun is shining; at night they bury themselves in the sand for protection.

The common fence lizard, *Sceloporus undulatus* (Fig. 60), is a small lizard from 5 to 6 inches long, it occurs from the Atlantic to the Pacific and from Canada to the Gulf, being most abundant in dry pine woods. It is a very active lizard, most at home in trees and on fences near the ground. Its color is grayish crossed with wavy black lines. The throat and the sides of the belly are bright metallic blue in the male, less brilliant in the female.

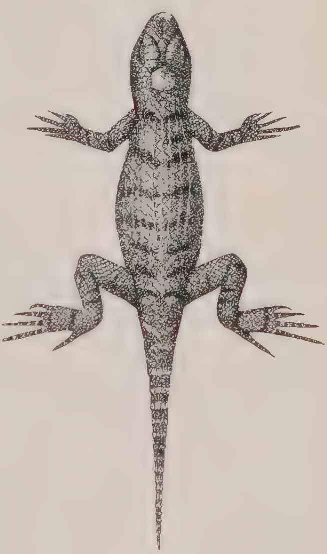


Fig. 60.—Fence lizard. *Sceloporus undulatus.*

The collared lizard, *Crotaphytus collaris*, lives in the great Southwest ranging eastward to the Great Plains. It is a rather large lizard with a heavy body, a long tail and stout hind legs. This lizard is brightly colored being grayish-green with a whitish or yellowish ring around the neck which is bordered with black. This lizard runs swiftly on its hind legs after the manner of some of the ancient fossil reptiles.

The chuck-walla, *Sauromalus obesus*, is a heavy-bodied, dull-colored, short-tailed lizard found in the deserts of the Southwest. It sometimes reaches a length of 1½ feet and is a sluggish creature, revelling in the hot sun of the desert. It is sometimes used for food.

The spotted lizards, *Holbrookia spp.*, include some 6 species of the Southwest that are rather local in their distribution. They are small lizards 4 to 6 inches long with two rows of dark spots down the back. They are peculiar among the swifts because the tympanum is hidden and the external ear opening is absent.

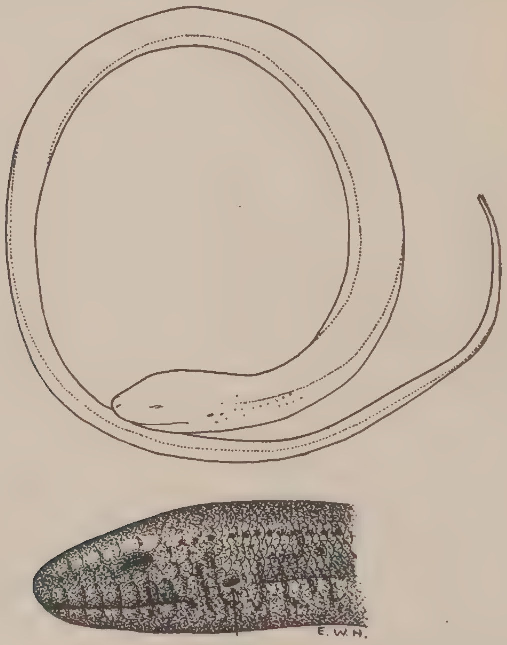


Fig. 61.—Glass snake. *Ophisaurus ventralis.* Head enlarged, showing external ear opening.

Family Anguidæ.—This family includes snake-like lizards with elongate bodies and long tails. The plated lizards of the Western United States have short weak legs. There are about 6 species in this group but outside of the fact that they have long brittle tails there is nothing of special interest about them.

The glass snake, *Ophisaurus ventralis* (Fig. 61), is not a snake but a legless lizard with the body more or less snake-like. The eyelids are movable, however, and the external ear opening distinct, two characters possessed by no snakes. This lizard is fairly common in the Southern States. It is active and feeds on insects, eggs and small mammals. It reaches a length of 2 feet or more and the tail makes up about two-thirds of the length of the body. The tail is very brittle and is easily broken if the lizard is roughly handled. The animal later regenerates a new tail which is much shorter than the old tail.

Family Helodermatidæ.—This family includes the bead lizards, which are distinguished from the other lizards by the fact that the scales are hemispherical or bead-like. These lizards are stout-bodied with short, thick tails, and short, thick legs. This family includes the poisonous gila monster, *Heloderma suspectum* (Fig. 62), found only in Arizona and New Mexico. The gila monster is the only poisonous lizard in the United States. There is only one other species in this family. It is found in Mexico and Central America. These two lizards are the only poisonous lizards in the world. They have grooved teeth on the lower jaw. These grooves lead to poison glands. They may inflict a severe wound and the poison is said to be powerful enough to kill a man.

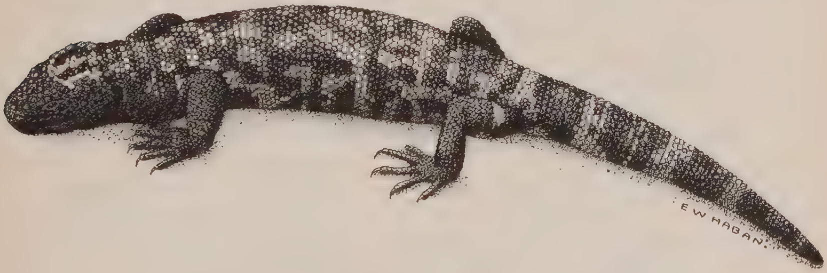


FIG. 62.—Gila monster. *Heloderma suspectum.*

Family Teiidæ.—Our species of this family are elongate lizards with longitudinal pale stripes or spots on a dark ground color. The tail is long and tapering. These lizards are very swift and are known as race runners. There are 6 species in this family. The common six-lined race runner, *Cnemidophorus sexlineatus*, is widely distributed in Eastern North America, common in the South. The other species are found in the Southwest from Texas to California.

Family Scincidæ.—This family contains the skinks or scorpion lizards, and the ground lizard. The common skink, *Eumeces fasciatus*, is widely distributed in the eastern United States, more common in the South. The young have the body dark with five longituinal yellow stripes on the back and the tail bluish. The adults are brown with the head red. These forms are commonly called scorpions and are believed to be dangerously poisonous although they are harmless.

The ground lizard, *Leiolopisma laterale,* is a smooth, shining, brownish lizard, the smallest of our North American lizards having legs, being only about 3 inches long. It ranges over the eastern states, common southward.

The Chief Value of Lizards to Man.—The lizards are of little value to man. A few forms like the iguanas of tropical America, the chuck-walla of the western states and others are used for food. But to most people the thought of lizard meat is abhorrent. Some forms, like the American chameleon and the horned toads, are sometimes kept as pets or curios but they have never been very popular.

Order Ophidia.—This order includes the snakes or serpents. A snake may be defined as a legless reptile, with an elongate tapering body not evidently divided into neck, trunk and tail and without external ear openings or movable eyelids. This group is generally feared and despised; although many members of the order are among the most harmless of creatures.

Family Boidæ.—This family includes the boa-constrictors of South America which reach a length of 12 feet, and the various pythons of Africa and India which range in size from about 15 to 30 feet. These are the largest snakes and their size is often greatly exaggerated. There are two North American species in this family the rubber snake, *Charina bottæ,* of the West and the boa, *Lichanura roseofusca,* of the Southwest. Both of these snakes are small, from 18 inches to 3 feet long, with short stumpy tails. Like the other members of the family they have remnants of the hind limbs indicated by a pair of short spurs in the anal region. No other North American Snakes have these rudiments.

Family Colubridæ.—This is the largest family of snakes and includes the most of our common North American forms, as about 100 species are known. These snakes are provided with many conical teeth. The eyes are well developed. For convenience the family is divided into two series *Aglypha* (*A,* without; *glypha,* grooves) and *Ophisthoglypha* (*Opistho,* behind; *glypha,* grooves).

The aglypha includes the harmless colubrine snakes, without any grooved teeth or fangs. This series includes most of our North American snakes. Brief discussions will be given of the more common forms.

The rainbow snake, *Abastor erythrogrammus,* and the horn snake, *Farancia abacura,* are large black snakes 5 to 6 feet long with the belly red, blotched with black. The back of the rainbow snake has three red stripes, while in the horn snake the back is uniform black. Both snakes are burrowing snakes but are sometimes turned out by the plow or the hoe. They are fairly common in the South Atlantic and Gulf States.

The ring-neck snakes, *Diadophis spp.,* are small burrowing snakes often found under decaying logs where they are searching for earthworms on which they feed. Our common eastern species is dull black in color with a yellow ring around the neck.

The hog-nose snakes, *Heterodon spp.* (Fig. 63), are peculiar burrowing snakes with the tip of the nose turned up. The 3 species are widely distributed but these snakes are more common in the South. The spreading adder is the most familiar hog-nosed snake in the East. It varies greatly in color being grayish, brownish, or reddish, with darker patches on the back. It has the habit when disturbed of hissing, blowing, spreading the neck, and striking with its mouth closed. Although it is generally accepted that this snake is poisonous, it is absolutely harmless. The hog-nose snakes in general feed on toads and frogs.

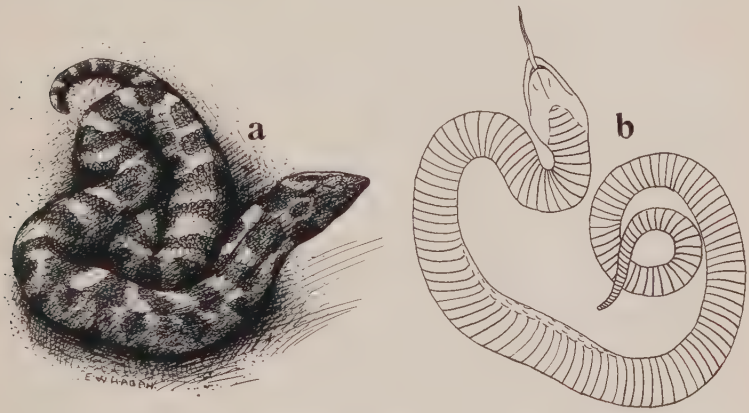


Fig. 63.—Hog-nose snake. *Heterodon contortrix.* *a*, normal position; *b*, "playing possum."

There are 2 species of green snakes in North America. The one may be known as the northern green snake or grass snake, *Liopeltis vernalis*, as it is found more commonly in the Northern States and prefers to live in the grass. The other may be known as the southern green snake, *Opheodrys æstivus*, as it is found principally in the South. It is a more arboreal species than the northern green snake and spends most of the time in bushes or trees. They both live chiefly on insects and as they are perfectly harmless they may be considered as beneficial. Their gentle ways, graceful habits, and beautiful colors should afford them protection wherever they are found.

The genus *Coluber* contains elongate swift-moving snakes which are known commonly as black snakes, blue racers and coach whips. The common black snake, *Coluber constrictor*, is generally distributed from the Atlantic to the Great Plains. It is uniformly black except the chin and throat which are white. It reaches a length of 6 feet and is generally feared. When cornered it can fight and as the teeth are fairly long and sharp it can bite but it is not poisonous. Neither is it a constrictor. The constricting snakes belong to the family Boidæ. This snake feeds commonly on rats and mice and is valuable and should be protected.

The blue racer is now generally considered a variety of the black snake. It ranges from the Mississippi River to the Pacific. It is blue-black or greenish above and its belly is yellowish. Its general habits are like the common black snake.

The coach whip, *Coluber flagellum*, reaches a length of 7 feet or more. It is a southern snake, occurring from the Atlantic to the Pacific. It is brownish in color and the scales are large giving it a braided appearance, this together with its long slender form suggested the name coach whip. It feeds on rodents and other small mammals and on birds.

The chicken snake, *Elaphe quadrivittata*, is a large yellowish-brown snake with four dark brown stripes. It is frequently 5 feet or more long and is a very powerful snake. It comes into barns seeking rats and mice and sometimes kills and eats chickens. A better name for this snake would be rat snake but the name chicken snake is so firmly fixed that it cannot be changed. This is a snake of the southeastern states.

The corn snake, *Elaphe guttata*, is one of our most beautifully colored snakes. The back is reddish-brown with a series of crimson spots bordered with black, a large one on the back and a small one on each side. The belly is whitish with black spots. It feeds apparently on mice more than any other food. It often reaches a length of 5 feet. It is confined to the South Atlantic and Gulf States.

The pilot black snake, *Elaphe obsoleta obsoleta*, is a large blackish snake reaching a length of 8 feet. The throat is white, as in the common black snake, but it can be recognized on close examination by the presence of a keel on each scale. This snake occurs throughout eastern North America as far west as Texas.

The fox snake, *Elaphe vulpina*, is found in the North Central States. It averages about 3½ feet long. It is yellowish-brown in color with a series of dark-brown blotches down the back, a large median blotch and a smaller one on each side. It is often common around barns where it feeds on rats and mice.

The indigo snake, *Drymarchon corais couperi*, is one of the largest snakes in eastern North America, reaching a length of 9 feet. Its blue-black color suggests its name and also gives it a general resemblance to our common black snake. It frequents barns looking for rats and mice. This snake occurs generally in the Gulf States.

The bull snakes, *Pituophis spp.*, are large snakes often 7 feet long or longer. They produce a loud hiss that sounds more like a bellow than anything else, hence the name bull snakes. They are generally whitish or yellowish-brown, marked with irregular dark blotches on the back. These snakes are more common in dry pine woods and are often called pine snakes.

The king snakes, *Lampropeltis spp.*, include a group of snakes that are famous because they are not affected by the bites of poisonous snakes. The color of these snakes is very variable and difficult to describe. Typical examples only will be described below and the study of the many varieties will not be considered. The largest of this group is the common king snake or chain snake, *Lampropeltis getulus*. It is black with creamy bands and lines united to form chain-like markings. It is usually held in high esteem because it is supposed to be the deadly foe of rattlesnakes and other poisonous snakes.

The milk snake, *Lampropeltis triangulum*, is a small snake about 2½ to 3 feet long. Typical examples are rather brightly marked having large black bordered, reddish-brown saddles on the back separated by grayish bands, and the belly reddish. These snakes occur commonly about barns and stables hunting for mice; this has led to the popular superstition that they milk cows.

There is also a group of king snakes including several varieties that may be known collectively as scarlet king snakes, *Lampropeltis amaura*. Typically these snakes are colored bright red, black and white or yellowish, arranged in bands. Thus these snakes resemble in a general way the poisonous coral snakes. In the scarlet king snakes, however, the red bands are bordered with black bands which are separated by whitish bands. In the coral snakes, the red rings are bordered by yellow rings which are separated by black. These color differences might be expressed in the following formulæ:

Scarlet king snake = Black — red — black-white — black — red —black, etc.
Coral snake = Yellow — red — yellow — black — yellow — red — yellow, etc.

The water snakes, *Natrix spp.*, are fairly large aquatic snakes averaging 2 to 4 feet in length but appearing much larger because they are thick-bodied and heavy. They are usually dull brownish or blackish in color, sometimes with yellowish stripes and sometimes with blackish blotches. They are found around ponds and along streams. They are most frequently observed on floating logs, or on rocks, or on the horizontal limb of a tree overhanging the water. They feed on frogs and toads commonly. Their teeth are long and they can bite severely and as they have vicious tempers when cornered they are much feared. For these reasons these snakes are commonly called water moccasins a name that should be reserved for the poisonous snakes and these non-poisonous snakes should be called water snakes. The water snakes are viviparous, retaining the eggs until they hatch and bringing forth living young.

The garter snakes, *Thamnophis spp.*, are a large group of small or medium-sized snakes widely distributed in this country. Typically they are olive-green or blackish in color with a dorsal and a pair of lateral pale yellow or orange-yellow stripes. These snakes are generally well known. They occur quite commonly in gardens and about human habitations. They feed on frogs and toads commonly. The garter snakes, like the water snakes, are viviparous.

We will bring the great series of Aglypha or non-poisonous snakes to a close with a brief consideration of the brown snakes. This is a group of small snakes from 10 to 15 inches long representing 5 genera and 6 or 7 species. They can all be lumped together because they are all grayish or chestnut-brown in color, often with a pale dorsal stripe and whitish or reddish bellies but otherwise without distinct markings. All are secretive snakes living under logs and stones and feeding on insects, earthworms and the like. All the brown snakes are viviparous, bringing forth from 18 to 36 young at a time. All the brown snakes are gentle creatures and might be used to typify all the Aglypha which are without exception non-poisonous snakes. They can all be classed as harmless as far as man is concerned. Some species have long teeth and can bite. There is, of course, danger from infection from such bites but the teeth of these snakes are not nearly as long as the teeth of a mouse and the bite of one of these snakes is not nearly as dangerous as the bite of a mouse. Yet common snakes are generally feared and shunned because a few of our native snakes are poisonous.

The opisthoglypha series of snakes include those members of the *Family Colubridæ* that have permanently erect grooved fangs in the back of the mouth. All are poisonous. Only 2 species are found in the United States. One of these, the crowned tantilla, *Tantilla coronata*, occurs in the South Atlantic and Gulf States. It is a very small snake about 10 inches long. Its bite is poisonous but it is not considered dangerous to man because of its small size. The body is brown, the head black with a pale ring around the neck. These snakes are often mistaken for the common ringed-neck snakes.

The other opisthoglypha are chiefly tropical in their distribution and are found in South America and the East Indies.

Family Elapidæ.—This family includes poisonous snakes with a pair of permanently erected fangs in the upper jaw. These fangs have a canal their entire length through which the poison is conveyed to an opening at the tip. This family is found chiefly in Africa and India. Only 2 species of coral snakes are found in the United States.

The eastern coral snake, *Micrurus fulvius*, is a medium-sized burrowing snake which occurs throughout the South Atlantic and Gulf States. It is brilliantly colored with bands of yellow, red and black arranged with the red bordered with yellow. It is a dangerously poisonous snake and the majority of the persons bitten by this snake die. The coral snake should not be confused with the harmless scarlet king snakes which have been discussed. The western coral snake, *Micrurus euryxanthus*, occurs in the arid Southwest. It is similar to the eastern coral snake but the head in the western species is red whereas in the eastern species it is black.

The *Family Elapidæ* includes not only the coral snakes but the dangerously poisonous cobras, *Naja spp.* (Fig. 64), of the African, Indian and Australian regions. These snakes are frequently of large size, some species 10 or 12 feet in length. These snakes are usually provided with a definite hood or expansion of the skin in the neck region which can be spread by a series of long ribs. These ribs lie next to the back bone when the snake is not excited. For large snakes the cobras have relatively very small fangs, so short that they cannot bite through ordinary clothing. Yet these snakes take their toll of human life among the bare-legged natives of India at a rate estimated at 25,000 annually. Simple clothing and the education of the people away from the belief that these snakes are sacred would eliminate this loss of life.

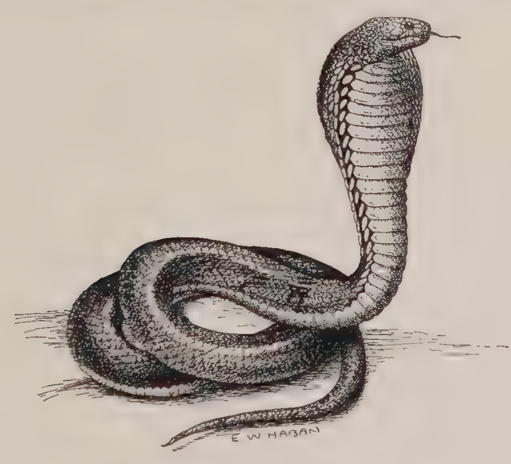


Fig. 64.—Cobra. *Naja sp.* (After D'Orbigny.)

Family Viparidæ.—This family and the next agree in having long erectile hollow fangs in the front part of the upper jaw. They are all poisonous, the poison destroying the red blood corpuscles. This family is confined to the Old World and contains the true viper, *Vipera berus*, and the puff adder, *Bitis arietans*. The group is mentioned because our European ancestors on settling this country fastened these names quite commonly and indiscriminately on colubrine snakes of North America, which are harmless to man.

Family Crotalidæ.—This family contains the poisonous pit vipers. Like the true vipers they have long erectile fangs in the front part of the upper jaw. When a large snake of this group strikes, the fangs cut deeply and as the opening of the poison duct is near the tip of the fang, the poison is left deep in the wound. This group contains our most common and largest poisonous snakes. All the species of this family have a pit that looks like an extra nostril between the true nostril and the eye. The function of this pit is not known. The pupil of the eye in our pit vipers is long and slit-like, like the pupil of a cat's eye in bright light. All our harmless snakes have a circular pupil, like the pupil of cat's eye in the dark. All our pit vipers are viviparous, bringing forth living young like the water snakes and the garter snakes. Our species may be divided into two groups: the rattlesnakes, with rattles on the end of the tail, and the moccasins, without rattles.

The rattlesnakes, *Family Crotalidæ*, are represented in the United States by 18 species. Rattlesnakes are most abundant both as to species and individuals in the arid Southwest. They seem to be primarily snakes of bare rocky regions and sandy deserts but some species live in wet meadows and some in the woods.

The massauga, *Sistrurus catenatus*, is a medium-sized rattler about 2½ to 3 feet long of the Great Plains region occurring quite commonly in low, wet meadows and feeding on frogs. It is quite often encountered in harvesting wild hay in wet meadows. Its bite is dangerous but seldom fatal if given the proper treatment. It apparently seldom bites man.

The ground rattlesnake, *Sistrurus miliarius*, is the smallest of our rattlesnakes and while the bite is painful it is not dangerous if promptly treated. This snake averages about 20 inches long.

The common rattlesnake, *Crotalus horridus*, is widely distributed in eastern North America. It lives chiefly in rocky woods, hence is often called timber rattlesnake, and reaches a length of 6 feet. It is marked with irregular cross bands and is frequently called banded rattlesnake. Because of its large size this snake is a dangerous reptile and its bites should always be treated promptly and thoroughly.

The diamond-back rattlesnake, *Crotalus adamanteus* (Fig. 65), is the largest of our North American rattlesnakes. It reaches a length of 8 feet or more and may measure 4 inches across the top of the head. Its general color is olive-brown with slightly darker diamond-shape marks on the back outlined with grayish-brown. The distribution of this reptile is in the South Atlantic and Gulf Coast States, occurring most commonly in swamps, and low wet savannas. The bite of this snake is the most dangerous of any of the North American snakes. The bite of a large one is always fatal.

The side winder, *Crotalus cerastes*, is a small rattlesnake of the desert regions of the Southwest averaging about 20 inches in length. It receives its name from its peculiar sidewise method of locomotion.

The Texas rattlesnake, *Crotalus atrox*, is next to the diamond-back our largest rattlesnake, it ranges from Texas westward to California. It is usually pale in color and blends well with the desert sands.

The prairie rattlesnake, *Crotalus confluentus,* occurs in the Great Plains region. It is rather large in size, averaging 4 feet. It is a dangerous reptile and should always be treated with respect.

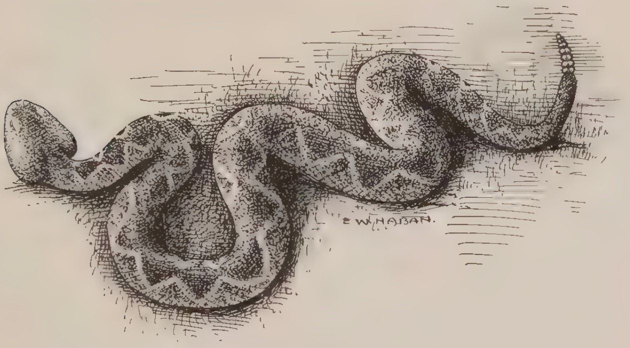


FIG. 65.—Diamond-back rattlesnake. *Crotalus adamanteus.*

The pacific rattlesnake, *Crotalus oreganus*, occurs over the entire Pacific Coast area. It is of fairly large size, about 3½ feet in length.

The moccasins include two North American snakes, the copper head or highland moccasin and the water moccasin or cottonmouth. Both are thick-bodied, sluggish snakes, generally credited with having vicious tempers but in the writer's experience with a limited number they are gentle snakes that only strike on the greatest provocation.

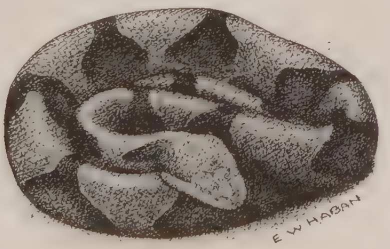


FIG. 66.—Copperhead snake. *Agkistrodon mokasen.*

The copperhead, *Agkistrodon mokasen* (Fig. 66), is a beautiful light brown snake with irregular dark brown leaf-like markings, which account for such names as white oak snake from a fancied resemblance of these dark markings to dead white oak leaves. The head usually has coppery reflections. It occurs throughout the eastern United States and seems to be equally at home in swamps, in sandy areas, in dry upland woods, on rocky hillsides, or mountains. It feeds on rodents, birds, snakes and frogs. Its bite is very dangerous but not usually fatal if properly treated.

The true water moccasin, *Agkistrodon piscivorus*, is a snake that is at home only in the swamps along the coast of the South Atlantic and Gulf States. It is obscurely blackish or brownish in color often with darker markings. It is a thick-set snake and might easily be confused with the non-poisonous water snakes. It feeds on frogs and fish principally but will eat warm blooded vertebrates as well. Its bite is dangerous but not necessarily fatal.

Poisonous Snakes.—It can be seen from the above account that our common poisonous snakes all belong to the pit vipers. The majority of these can be recognized because they have a rattle on the end of the tail. That leaves only 2 species of moccasins to be recognized, the water moccasin and the copperhead. Their recognition is simple and easy. These two snakes are first of all thick bodied, sluggish snakes, usually dull brown or blackish-brown in color. Both have short, triangular, flat heads with slender necks. Both have a pit on the side of the head between the nostril and the eye, which can be distinguished at a safe distance. There is, therefore, no need to confuse our common poisonous snakes with the non-poisonous snakes. There is, furthermore, absolutely no excuse for the indiscriminate destruction of snakes in the hope that a few poisonous individuals may be killed. Most of our non-poisonous snakes are highly beneficial as they destroy large numbers of rodents. A few of our non-poisonous snakes feed to a large extent on frogs and are neither markedly beneficial nor injurious. A still smaller proportion of these snakes feed on beneficial birds or their eggs and on the valuable toad and are, therefore, injurious. But this latter group includes such a small percentage of the total snake population that it may be disregarded. There is, therefore, no excuse for anyone not learning the difference between the harmless beneficial snakes and the dangerous poisonous ones. How ridiculous it is to contemplate a great big 6-foot man, whaling away at a poor little innocent garter snake 1½ feet long with a club as thick as your arm and as long as can be wielded.

How Poisonous Snakes Bite.—All pit vipers (Fig. 67) bite in the same way. The fangs are fastened to the movable maxillary. The mandible is hinged to the skull by the long quadrate bone. When the lower jaw is pulled down and the mouth is opened the quadrate acting through the pterygoid, or transverse bone, forces the fang forward to the erect position. When the mouth is closed the fang rests against the roof of the mouth. The same mechanism that opens the snakes mouth forces the poison from the poison gland at the side of the upper jaw through the poison duct to the end of the fang where it is left in the wound. Our pit vipers are provided with a whole series of extra fangs which are formed in the jaw just behind the functional fangs and are ready to take the place of the functional fangs as these are frequently pulled out when the snake strikes. Thus the common supposition that you can make a pit viper harmless by extracting his fangs is erroneous. Even if all the fangs were extracted there would still be some danger because the teeth of the pit vipers are long and capable of piercing the human skin and poison from the poison duct could be poured readily into such a wound. People that handle rattlesnakes frequently adopt the expedient of allowing the snake to strike a piece of meat repeatedly hoping thus to get all the poison out of the poison glands.

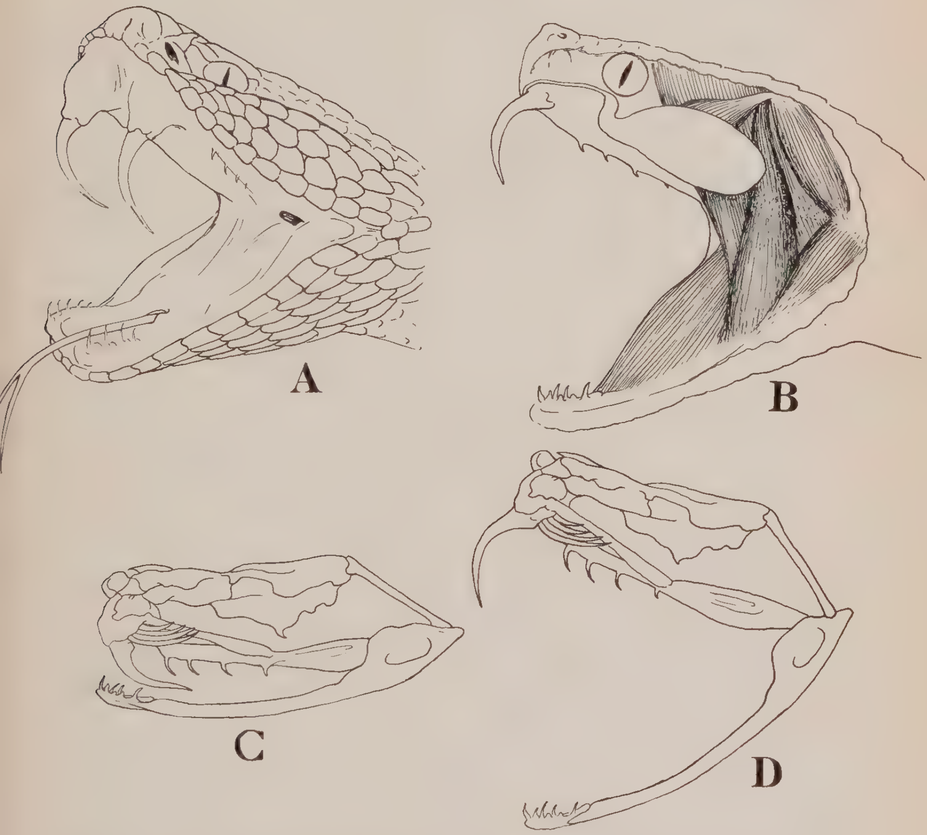


Fig. 67.—*A*, head of rattlesnake, showing fangs, teeth and tongue; *B*, head dissected, showing muscles, poison sack and duct; *C*, skull, showing position of fang with mouth closed; *D*, position when striking.

Remedies for Snake Bite.—The chief remedy for snake bite at the present time is anti-venom serum. If it is available, it should always be used. And if a person is going into a region where there is danger from snake bite, the anti-venom serum should always be carried. Anti-venom serum is made by injecting a horse with a small amount of venom and gradually increasing the amounts until the animal is immune. Blood is then drained from the horse and the serum prepared from the blood.

If a doctor is not available and there is no serum available, then it is advisable to take the following steps. Assuming that the bite is on the lower part of the leg, where the majority of snake bites occur, a ligature should be placed between the wound and the heart and drawn tight. A rubber ligature should be used, if available, but a simple ligature may be made by loosely knotting a handkerchief around the limb and then twisting it with the aid of a stick until it is tight. The wound should then be drained to remove the poison. This can only be done by cutting across the wound in both directions, taking care not to cut much deeper than the wound, but to cut deep enough so that the blood will flow freely. After the wound has commenced to drain it should be washed with a strong solution of potassium permanganate. This chemical oxidizes the venom and renders it harmless. After the wound has been thoroughly washed the ligature should be removed, as it is not advisable to stop the flow of the blood for more than a half hour or so. It is not advisable to suck the wound because there may be open sores about the teeth and if the poison should enter these sores there would be no way to counteract it. It may be necessary to give a stimulant to the patient but as a general rule stimulants should be given only on the advice of a competent physician. Special precautions should be taken to keep snake bit wounds protected as they are very prone to infection.

Order Crocodilia. The order crocodilia includes the crocodiles and the alligator. These are large lizard-like reptiles with the skin containing bony or horny plates, with a long head, a short neck, a robust body, stout legs, and an elongate tail which is slightly compressed. These are strictly aquatic reptiles that occur in the tropical and warm temperate regions of the world. They live in swamps, rivers and ponds. The eyes and nostrils are elevated so that the animal may rest in the water with only a very small part of the head exposed. The external ear opening, which lies just behind the eye, is covered by a bony flap which closes down tight when the animal submerges. The teeth are elongate and sharp pointed and placed in separate sockets. They are constantly being shed and replaced by new teeth from below. The tongue is short and thick and provided with a transverse fold which meets a similar fold from the palate. These two folds can separate the oral cavity from the pharynx completely, so that an alligator can drag its prey under the water without getting water into the lungs. According to some observers food cannot be swallowed under the water.

Two species of this order occur in North America, the crocodile and the alligator (Fig. 68). The former is found from southern Florida through the West Indies, and Mexico to South America. The latter is found in the South Atlantic and Gulf States. The crocodile has a triangular-shaped head and the alligator has a blunt head but otherwise in essential details of structure and in habits the two animals are similar, hence only the alligator will be discussed as it is the more abundant animal in North America. Alligators spend much of their time during the day basking in the sun on a log or on the bank. They are powerful swimmers using the tail as a propeller. The legs are not used in swimming but are folded backward against the body. They feed on such animals as they can secure and their bill of fare includes pigs, muskrats, water birds, water snakes and fish. The mating season is during late spring and early summer. The eggs are laid in nests composed of a mass of rotting vegetation, 6 or 8 feet in diameter. Several dozen eggs may be laid in a nest. The female often remains in a hole near the nest but apparently makes no effort to protect it. While a large alligator can inflict severe wounds with its sharp teeth or a dangerous blow with its powerful tail, alligators in their native haunts are not dangerous to man unless cornered or wounded. The African crocodile is a man-eater but our alligators seem to prefer to escape.

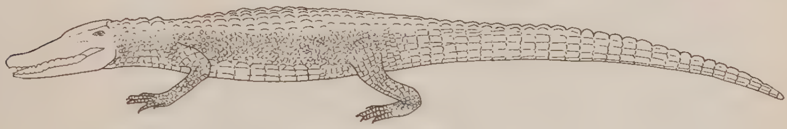


FIG. 68.—Alligator. *Alligator mississippiensis.*

The Economic Importance of the Alligator.—The chief economic importance of the alligator is as a source of leather. This leather is used chiefly for hand-bags, pocketbooks and belts. In 1900 more than 250,000 alligator hides were tanned in the United States. Since that time both the supply and the demand have decreased, and alligator leather is now of little economic importance.

The flesh and the eggs are both used for food. Those who have eaten carefully prepared alligator meat pronounce it palatable, but the almost universal prejudice against the flesh of all reptiles save the turtles will certainly prevent alligator flesh from becoming popular.

Many small alligators are sold each year as curios to tourists. For this purpose the small recently hatched alligators seem to be the most popular. Unfortunately, most of these alligators are not properly fed and cared for and soon die.

SOME POPULAR SUPERSTITIONS ABOUT REPTILES.

There are so many popular superstitions about reptiles, so much information that is false that it seems worth while to analyze some of the more important of these.

That all reptiles are poisonous is a very general belief. How far this is from the truth may be appreciated from the above survey. A poisonous reptile is one that is provided with a poison gland which secretes a fluid that attacks either the nervous system or the red blood corpuscles and causes the death of the prey. Reptiles might therefore be poisonous to other animals without being fatal to man. On this basis all our turtles, all our crocodiles, all our lizards, save the gila monster would be listed as non-poisonous reptiles. In the snakes there are four species of American opistoglyphs that are poisonous although three of these must be classified as not dangerous because of their small size. The coral snakes in North America comprise 2 species both dangerous to man. The pit vipers contain 2 species of moccasins and 18 species of rattlesnakes in North America. All the pit vipers may be considered dangerous to man, although some of the species are too small to be considered fatal to man. Outside of these few species of snakes and the one lizard all the rest of our reptiles are non-poisonous. Common water snakes, blacksnakes, spreading adders, and a host of others popularly supposed to be poisonous are non-poisonous. The belief that some of these are poisonous is so firmly fixed that it is worth while to discuss them in detail.

The green snake is not poisonous. Yet there is a prevalent notion that the bite of this snake will cause the color of the flesh to turn green. Nothing could be more ridiculous. The teeth of the green snake are not long enough to pierce the human skin, even if it wanted to bite. But the green snake is an exceedingly gentle creature. It may be abused until one becomes ashamed of one's self but it cannot be forced to bite.

Then there is the case of the spreading adder. It both looks and acts the part of a dangerous reptile. It hisses, it strikes with the mouth shut, not open, it spreads out the skin of the neck in a broad flat hood like a cobra, it puffs and blows but authentic cases of persons having been bitten by spreading adders are not known. There are, however, plenty of people who have heard of someone who was bitten by a spreading adder.

The truth of the matter is that the spreading adder is a big bluff. If one is cornered it will put on a good show but if it is handled a little rough it will turn over on its back and play possum. But apparently this great actor is thoroughly convinced that no snake is a good dead snake unless he is lying belly up, for if you take a specimen that is playing possum and turn it right side up it will immediately flop over. A specimen that recently came to hand went one step further in the game of playing possum, it lolled out the tongue thus adding an artistic touch to the picture of a dead snake. If an adder that is playing possum is left undisturbed, it will slowly right itself and crawl away to safety.

Then there is the ancient belief that a blacksnake will chase a person. Just what it is to do with the person if it should catch him is always left to the imagination. There is no doubt that if a person were going in the same direction that a blacksnake was going, and if he kept on in that direction, and if his wind held out, and if his speed held out, and if the snake did not change its mind, that a speedy blacksnake might run a man to death but there are a good many ifs in this proposition.

Another popular fancy about snakes is that they bite with their tongues. Even the most superficial examination would show how ridiculous this is. The tongue of the snake is very flexible like our tongues. It is perhaps an important sense organ, perhaps of touch or it may be able to perceive vibrations or sounds. But no snake bites with its tongue. All snakes bite with their teeth, and in the poisonous snakes some of these teeth are modified as hollow or grooved fangs.

The belief that snakes swallow their young is all but universal. Yet it cannot be demonstrated in the laboratory the real test of science. An observation not supported by experiments will not do. The supposition is that snakes swallow their young for protection and then regurgitate them later. Now most of our snakes lay eggs in the ground and leave the sun to hatch the eggs. If an oviparous snake ever sees its young it is purely an accidental encounter, not because the mother went back to see if the eggs hatched or to see if the young were in danger and ought to be swallowed. Some of our snakes give birth to living young. This group includes water snakes, the garter snakes, the brown snakes, and the pit vipers and others, but there is no evidence to show that even in these cases the young remain long with their mother under natural conditions. As a matter of fact all the evidence would seem to indicate that the young soon shift for themselves. It is from this group of viviparous snakes that this story undoubtedly arose. These viviparous snakes are among our most common kinds and it takes no great feat of the imagination to believe that mother snakes about to give birth to living young have been killed repeatedly. What is more natural than when a snake of this kind is crushed that the young should crawl about? What more natural than for the observer, not familiar with the life histories of viviparous snakes, to assume that the young snakes had been swallowed?

The hoop snake and sting snake myths are usually combined into one. The hoop snake takes its tail in its mouth and rolls along like a hoop. The sting snake has a sting in the end of its tail with which it stings even trees, causing their death. Now the fact that no zoölogist or herpetologist, whose business it is to study snakes, has ever seen this peculiar mode of locomotion or that no observer has ever been able to produce a snake that could roll along with its tail in its mouth may be very interesting but to the believer in such tales they are not important facts.

Furthermore, the fact that there is nowhere in the world a snake with a sting in the end of its tail does not prevent this tale being repeated for the entertainment of a credulous audience.

The fancy that milk snakes enter barns and milk cows dry is widely accepted. A cow dries up either naturally or because of some disease, the farmer sees a milk snake at the same time and presto two and two are put together and the snake was the cause. No questions are asked as to how a small-sized snake like a milk snake is to reach the teat of a cow, or how it could swallow several quarts of milk. The observation is made and the conclusion drawn. The unfortunate thing about this tale is the fact that the milk snake is not recognized as one of the best rat and mouse catchers and protected fully.

Another popular fancy is that you can tell the age of a rattlesnake by the number of rattles on the end of the tail. This has no basis in fact at all. Repeated observations have shown that two or three rattles may be formed in a year if the animal is well fed, on the other hand rattles are easily broken off. So that the number of rattles on the end of a rattlesnake's tail is not a reliable index to the age of the snake.

Another popular fancy is the one that the glass snake sheds its tail and then goes back and pieces the parts together again. The facts are these. The so-called glass snake, which is a legless lizard, has a tail that equals about two-thirds the length of its body. If these animals are carelessly handled the tail breaks off just as it does in many lizards and salamanders, but of course the lizard is so glad to escape with the loss of his tail that it is perfectly willing to leave those parts never to return to hunt for the pieces. It does a much wiser thing. It proceeds to grow a new tail, by the process of regeneration.

These and many other tales have been told about reptiles. Space will not permit the further consideration of this interesting subject, but the acid test of all these cases is to get the actual observer to relate the circumstances and then see if the incident can be repeated. Most of these snake stories are told by someone who heard someone else tell the tale that someone else had seen the thing happen.

CHAPTER IV.

THE AMPHIBIA.

- Definition
- Classification
- Economic Importance
  - Frogs used as food
  - The toad as an insect destroyer
- Some Superstitions about Amphibia

DEFINITION.

Amphibians may be defined as cold-blooded vertebrates covered with a scaleless skin and with the body divided into head and trunk with the tail present or absent. Two pairs of limbs are usually, though not always present. There is usually a distinct metamorphosis (Fig. 69) the larvæ breathing by means of gills and the adults typically by lungs. The larvæ may live in the water and the adults on land, although some larvæ are strictly terrestrial and some adults strictly aquatic. The heart is made up of three chambers, two auricles and a single undivided ventricle. Both the right and left aortic arches are fully developed (Fig. 70).

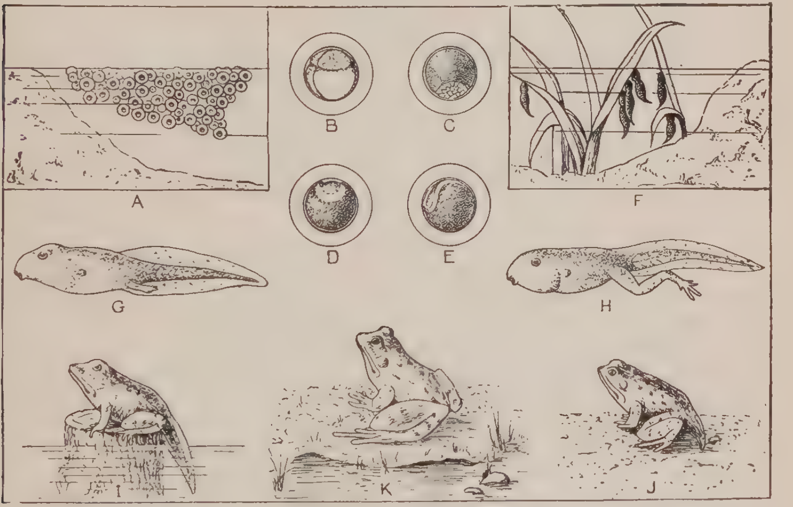


Fig. 69.—Development of the frog. *A*, eggs; *B*, *C*, *D* and *E*, cleavage, gastrula and neural fold stages; *F*, newly hatched tadpoles; *G* and *H*, later tadpole stages; *I*, *J* and *K*, metamorphosis to juvenile frog. (Reprinted by permission from "Text-book of Zoölogy," by W. C. Curtis and M. J. Guthrie, published by John Wiley & Sons, Inc.)

CLASSIFICATION.

Our North American amphibia may be grouped into two orders: *Caudata* or salamanders and *Salientia* or toads and frogs. The Caudata are tailed Amphibia and the Salientia are tailless Amphibia. The following outline of classification will serve to place our common North American forms:

ORDER CAUDATA.
    Family Necturidæ—Mudpuppies.
    Family Amphiumidæ—Congo eels.
    Family Cryptobranchidæ—Hellbender.
    Family Sirenidæ—Mud eel.
    Family Salamandridæ—Newts.
    Family Ambystomidæ—Spotted salamander.
    Family Plethodontidæ—Slimy salamanders.

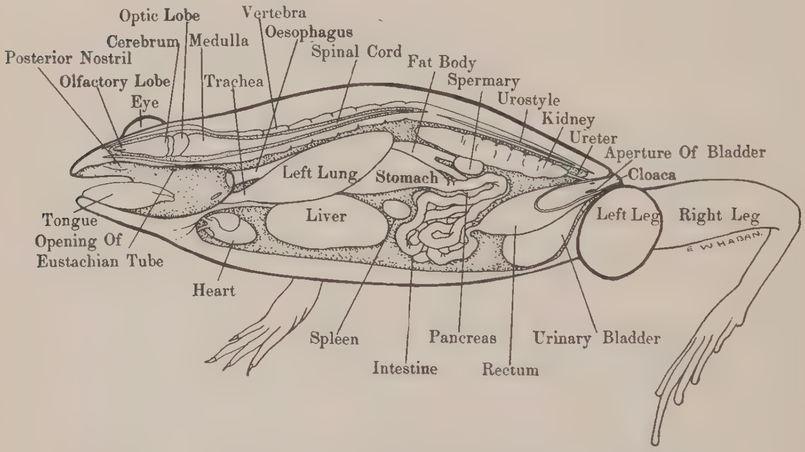

Optic Lobe
Vertebra
Cerebrum
Medulla
Oesophagus
Posterior Nostril
Spinal Cord
Fat Body
Olfactory Lobe
Trachea
Spermary
Eye
Urostyle
Kidney
Ureter
Aperture Of Bladder
Cloaca
Left Lung
Stomach
Liver
Left Leg
Right Leg
Tongue
Opening Of
Eustachian Tube
E W HAGAN.
Heart
Spleen
Pancreas
Urinary Bladder
Intestine
Rectum

FIG. 70.—Diagram of the frog, showing general internal structure.

ORDER SALIENTIA.
    Family Scaphiopodidæ—Spadefoot.
    Family Bufonidæ—Toads.
    Family Hylidæ—Tree frogs.
    Family Ranidæ—Frogs.

SOME COMMON AND INTERESTING AMPHIBIA.

Order Caudata.—*Family Necturidæ.*—This family includes the strictly aquatic mudpuppies. The mudpuppies are stout salamanders with two pairs of legs well developed, and the external gills well developed; the tail is compressed. These are large salamanders, averaging from 12 to 24 inches in length. Two species are known in North America. One lives in the Great Lakes and the streams and ponds in the Ohio Valley, the other in the streams of the South Atlantic States. They are slow, sluggish creatures but have a vicious bite. They eat such aquatic animals as they can capture including crawfish, insect larvæ, fish and frogs. They are sometimes caught on hooks and lines and the flesh is said to have a delicious flavor not unlike that of catfish. Since this animal is considered a reptile by most people, the flesh is not usually eaten.

Family Amphiumidæ.—This family includes the Congo eels, ditch eels or Congo snakes, *Amphiuma means* (Fig. 71). They are elongate eel-like or snake-like creatures without external gills but with a slit-like spiracle on each side of the head and internal gills. They average about 2½ feet in length. There are two pairs of weak legs which are barely functional. Two species are known in North America. They live in the bayous and sluggish streams of the South Atlantic and Gulf States. They feed on all sorts of aquatic animals and are occasionally found in swamps and rice fields.

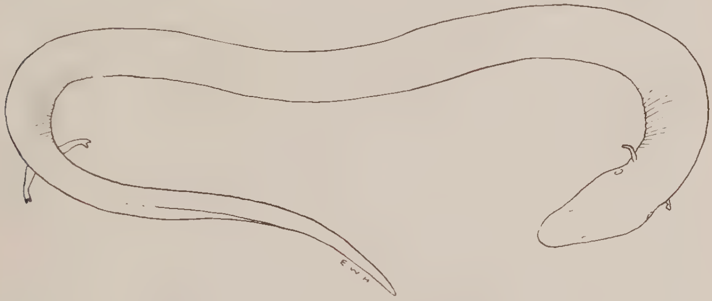


FIG. 71.—Ditch eel. *Amphiuma means.*

Family Cryptobranchidæ.—This family includes but a single North American species, the so-called hellbender or water dog, *Cryptobranchus alleganiensis.* In general shape they resemble the mudpuppies, being stout-bodied with strong limbs and a flattened tail. As far as their external characters are concerned they differ from the mudpuppies chiefly in having no external gills. The gills are internal and open through a pair of small openings on the sides of the neck. Our species lives in the Great Lakes drainage system and in the Mississippi Valley. They seem to prefer rocky bottoms to mud. They feed on all kinds of aquatic animals and are frequently caught on fish hooks, much to the disgust of the fisherman. They are usually thrown away although the flesh is excellent.

Family Sirenidæ.—This family includes the so-called mud eels, *Siren lacertina.* The body is elongate, eel-like or snake-like in appearance. These animals might be readily confused with the Congo eels. The mud eels have only one pair of legs, however, and have strongly developed external gills. We have 2 species in this family. One a large species 2½ feet long living in the South Atlantic and Gulf States and the Mississippi Valley. The other a small species 6 to 9 inches long living only in the South Atlantic States. These animals live in muddy pools in swamps and feed principally on insects, crayfish and other crustaceans.

Family Salamandridæ.—This family includes the newts (Fig. 72). These are small aquatic salamanders. Our common eastern species is from 3 to 4 inches in length but the Pacific Coast species is larger, from 6 to 7 inches. The eastern newt is widely distributed in streams in eastern North America, occurring westward to the Great Plains. It is a bright-colored little fellow, light green above, yellowish below flecked with small black dots. The sides are usually marked with a row of bright red spots. The eggs are glued fast to the under sides of the leaves or to the stems of aquatic plants. The larvæ that hatch from these eggs are aquatic with external gills and greenish in color. After living in the water for several months they come out on the land, lose their gills and become bright red in color. They live in the woods under leaves, rocks and logs for two or more years. When they become adult they lose their bright red color and return to water. These little salamanders are a worthy addition to any aquarium.

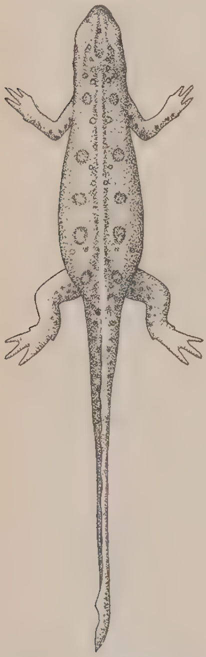


FIG. 72. -Newt. *Triturus viridescens.*

Family Ambystomidæ.—This family includes medium-sized salamanaders with cylindric bodies and stout tapering tails. The lungs are well developed and the adults are usually terrestrial, living near the water under stones and logs and returning to the water to lay their eggs. The eggs usually form a large gelatinous mass. The aquatic larvæ are provided with gills. In some species the larvæ remain in the water and become adult and lay eggs while still in the larval condition with external gills. Some of our species like the tiger salamander, *Ambystoma tigrinum*, and the spotted salamander, *Ambystoma maculatum*, are dark in color with conspicuous yellow spots or bands. In other species the spots are small or inconspicuous or may be wanting entirely. The Mexicans eat the larvæ of the common spotted salamander and esteem it highly.

Family Plethodontidæ.—This is a group of small-sized salamanders from 3 to 6 inches long. They differ principally from the Ambystomidæ in the absence of lungs. Respiration is carried on through the skin and in the pharynx. This is our largest family of salamanders. But since most of the species are small and secretive they are little known. Some of the species are aquatic and live in springs and quiet pools of streams and are known as spring lizards. Others live near streams and ponds in damp or moist situations, while the slimy salamander lives under logs in dry woods. Fertilization is internal and the eggs may be laid in the water or in damp situations. The females of some species hover over their eggs until they hatch. Some of the larvæ are aquatic, breathing by means of gills and some are terrestrial losing their gills on hatching.

Order Salientia.—The tailless amphibia include the toads, spadefoot, tree frogs and true frogs. Their general shape with short front legs, fitted for walking; stout hind legs, fitted for leaping; broad head with wide mouth and short tailless body is too well known to need further description. Our species lay their eggs in water. These eggs hatch into tadpoles which have gills and a tail. The gills are replaced by lungs, the legs develop, the tail is absorbed and the tadpole becomes a toad or frog.

Family Scaphiopodidæ.—This family includes the spadefoot, *Scaphiopus holbrooki*. The members of this family are medium-sized toads with a strongly developed spur on the hind foot. They are terrestrial burrowing animals spending the day in shallow burrows and coming out at night to search for their insect prey. In the spring after the first warm rain in April they resort to pools to mate and lay eggs. At this season of the year they make themselves conspicuous with their ear splitting calls. The eggs are attached to the stems of plants in the water. They hatch in about a week and the tadpoles have developed legs and come out on the land in about a month. After developing legs the young wander away from the water and dig their burrows like the adults do.

Family Bufonidæ.—This family includes the true toads. These terrestrial amphibians are too well known to need description. About 15 species are known in the United States. Some of these species are very local in their distribution, while others, such as the common toad, which is abundant all over North America east of the Rocky Mountains, the western toad which occurs from the Great Plains to the Pacific, and the Pacific Coast toad which occurs from Alaska to Lower California, are very widespread. The toads return to ponds, lakes, the quiet pools of streams and ditches to mate and lay eggs. Their weird calls, a long drawn out u-r-i — — —p, are familiar to everyone who has spent a summer evening near a pond. The eggs are laid in long strings, not in clumps like the eggs of frogs. These eggs are usually attached to plants. The tadpoles are uniformly black in color. Small toads leave the breeding pools and scatter widely. They hide away during the day and emerge at night to feed. Sometimes during rainy spells they appear in enormous numbers leading to the popular superstition that they rained down.

Family Hylidæ.—The tree frogs are small amphibians that live in the dense growths of swamps on the ground near the water, or in trees often some distance from the water. Some of these forms, like the common tree frog, *Hyla versicolor* (Fig. 73), have the fingers and toes ending in sucking disks and are able to climb trees, where they live on such insects as they can capture. Others such as the spring peeper, *Hyla crucifer*, the cricket frog, *Acris gryllus*, and the chorus frogs, *Pseudacris spp.*, have only small disks and live on or near the ground in swampy situations. All the tree frogs return to the water in shallow pools to lay their eggs in small masses. All the tree frogs have lusty voices. The common tree frog sings during wet weather. The spring peepers and the chorus frogs create a terrible din in swamps in spring. They are among the earliest amphibia to appear and their song period is usually interrupted by a number of cold spells. There is a common saying to the effect that "the spring frogs will look through the glass (ice) three times."

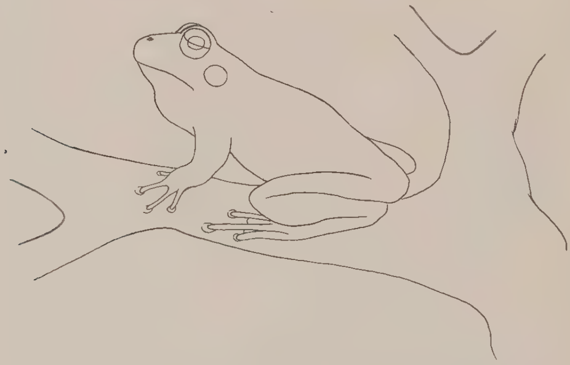


FIG. 73.—Common tree frog. *Hyla versicolor.*

The common tree frog is noted for its peculiar call which is especially conspicuous during the warm rains of spring and for its remarkable ability to change its color from ashy-gray to brownish-black. These adaptations in color to suit its surroundings make it very inconspicuous under natural conditions.

The swamp frogs are small Hylidæ, such as the spring peepers, the cricket frog and the chorus frogs that occur in great numbers in the early spring in swamps and wet meadows and make themselves conspicuous by their loud shrill calls.

Family Ranidæ.—This family contains smooth-skinned medium or large-sized, usually aquatic frogs. Although some species, such as the leopard frog, *Rana pipiens*, often wander into meadows far from water. This family includes our common large frogs such as the leopard frog, the bullfrog, the green frog, the pickerel frog, the wood frog and others. Many of our species have considerable economic value because the legs are used for food. The eggs are laid in globular or irregular masses or thin sheets in the water, usually attached to water plants. The eggs hatch into tadpoles, which are usually full grown the first summer, but the bullfrog and the green frog tadpoles require two summers to become full grown. Most of our species live largely on insects but as these insects are chiefly innocuous or even beneficial aquatic forms, frogs cannot be said to be beneficial animals.

The bullfrog, *Rana catesbeiana* (Fig. 74), is the largest of our frogs. It has a wide distribution in eastern North America, which together with its large size makes it a favorite frog used for food and its deep bass voice makes it one of our most familiar frogs. It may be distinguished from the other common frogs by the fact that its body is not conspicuously spotted, being greenish-brown in color, although the hind legs are often spotted. There are no ridges along the sides of the body. The common green frog, *Rana clamitans*, resembles the bullfrog in general but averages smaller, has evident lateral ridges and the head is brighter green than in the bullfrog.

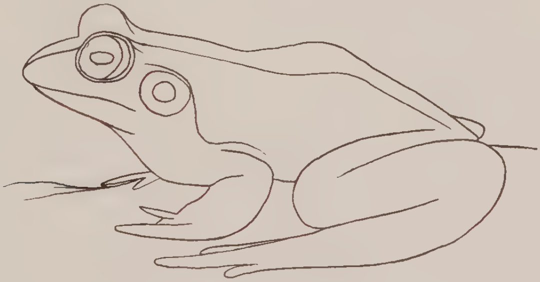


Fig. 74.—Bullfrog. *Rana catesbeiana.*

The leopard frog and the pickerel frog, *Rana palustris*, are our commonest spotted frogs. They average from 3 to 3½ inches in length with the upper parts with evident lateral ridges and conspicuous round or squarish, dark spots. Both these frogs are common along streams and about ponds, and both kinds frequent meadows in search of grasshoppers and other insects.

ECONOMIC IMPORTANCE OF THE AMPHIBIA.

The Frogs Used as Food.—The principal economic importance of the amphibia lies in the frogs that are used for food. According to the latest figures available from the Bureau of Fisheries about 250,000 pounds of frog legs worth about $50,000 are collected each year. The principal kinds used are the bullfrog and the green frog, although the leopard frog, the wood frog, the pickerel frog and some other species are sometimes used. The principal sources of the frogs sent to market are the swamps along the Atlantic Coast from Maryland to South Carolina and the swamps of the Mississippi Valley from Wisconsin and Minnesota to Louisiana and Mississippi.

Frogs are captured in various ways. The favorite device of boys is the fish pole, with the line baited with red cloth, worms, grasshoppers, or other insects; and this method is yet frequently employed by the market hunter. A more common method, however, is clubbing. Wet gunny sacks are used in their capture by being thrown over the frogs. Some expert froggers are very adept at catching them alive by hand. A frog catcher will hold one hand over or in front of the prey to attract its attention and capture the game by a sudden movement of the other hand.

Several methods are based on the migration of the frogs in the fall or spring. These methods of capture are used in the fall when the frogs migrate from the fields and swamps toward the lakes for hibernation. This migration is not regular; it takes place mostly at night, particularly during warm rains, after a light frost. Many reach the swamp in the fall, and many winter in the ravines and enter the swamp in the spring. In some cases roads or railroads form partial barriers and the frog catchers make use of these. A barrel placed at the swamp end of a culvert may yield numerous frogs which are traveling down the ravines. In Minnesota, frogs are caught in various ways, but chiefly in pits dug between sloughs and the adjoining high grass. The season for their capture in this manner is usually in the fall when they are returning to the water.

There are many other variations of the pit method. Sometimes screens about 18 inches high, supported by sticks, are placed along the shore to intercept the migrating frogs. At intervals of two or three rods postholes are dug to entrap the frogs which failing to surmount the screen, wander along it and fall into the traps.

In many regions, as in central New York and elsewhere, the professionals come to know where the frogs hibernate and often dig them out of the mud in large numbers. A favorite method of capture at night is to use a bull's-eye or any form of bright light. The frogs are dazed and in most cases can be caught by hand or approached near enough for their easy dispatch. The lantern may be on the prow of the boat, carried in the hand, or worn on the head, as with alligator hunters. The rifle and spear and gig are used mainly in Illinois, Arkansas, Missouri and Tennessee. The spear may be one of several sorts, three-pronged or single, or merely a nail or a straightened fishhook in the end of a pole.

Many attempts have been made to raise frogs on a commercial scale, but with very little success. About all that can be done in this way is to stock natural breeding areas with desirable species, to prevent excessive hunting, especially during the breeding season and to protect the tadpoles and young frogs especially, from their enemies. The list of enemies of the frogs is a long one and includes most of our common fresh water fishes, which destroy eggs and tadpoles in untold numbers. The turtles and snakes among the reptiles are great destroyers of frogs. Many species of snakes, especially the water snake, blacksnake and the garter snake feed very largely on various species of frogs. Among the birds the principal enemies of the frogs are the herons and bitterns, marsh-loving birds which feed almost exclusively on the frogs and their tadpoles. Some ducks feed quite commonly on tadpoles, and the common crow feeds on frogs, especially the smaller species and the young of the larger species.

The Toad as an Insect Destroyer.—The common toad is generally recognized as an important enemy of insect pests. Kirkland, who studied the feeding habits of the toad very carefully, came to the conclusion that insects made up about 90 per cent of its food. The number of insects eaten at a single meal is almost beyond belief, as may be noted from the following observations:

"On the evening of July 19, 1920, a medium-sized toad (Bufo fowleri Putnam) came to my porch where the common southern May beetle (Lachnosterna ephilida Say) was swarming about the lights. I soon noticed that this toad was devouring all of the May beetles that he could reach with his tongue, and after I had fed him a few it occurred to me that it might be a good thing to test his capacity for these beetles. The first night this toad ate 43 beetles in an hour and five minutes. The night of July 20, it ate 34 in forty-five minutes. The night of July 21, it ate 37 in an hour. The night of July 22, it ate 30 in an hour and a half. And the night of July 23 it ate 26 in two hours. On July 24, the flight of beetles was practically over and only 7 beetles came to the light in three hours. Usually the first 15 to 20 beetles would be eaten with apparently great relish, but after that it required considerable coaxing to get the toad to eat at all, and when the number eaten got to the thirties the toad would take his front feet and literally cram the beetles down his throat at the same time going through a series of contortions which seemed to put that beetle into its proper cranny. These maneuvers were very comical and reminded one of the actions of a small boy at a picnic trying to eat just one more piece of cake. In each case excepting the night of July 24 when the flight of beetles was practically over, the numbers given represent all that I could get the toad to eat. After it had eaten its fill it might look at a beetle placed before it but usually it turned its back on all such proffers, and if the efforts were persisted in, the toad hopped away from the porch in disgust.

"This represents a total of 177 May beetles destroyed in five days, and if each one of these eighty-eight pairs laid 100 eggs this one toad prevented the development of 8800 white grubs on my lawn.

"It is only fair to state that *Lachnosterna ephilida* is one of the smaller May beetles. It averages 15 millimeters in length and 7 in diameter and weighs when dry, about 150 milligrams.

"Assuming that these meals represent the average meals of a toad, it will be noted that a single toad would destroy the equivalent of 4200 May beetles in a season of four months."

SOME SUPERSTITIONS IN REGARD TO AMPHIBIANS.

It is to be expected that animals as common and so little studied as many of our amphibians are, would be a perennial source of many common superstitions. Some of the forms like the mudpuppy and the hellbender are unspeakably ugly and this has lead to the belief that many, if not all amphibians are poisonous. Some of our amphibians secrete an irritating liquid from glands in the skin. Many animals have discovered that toads and frogs secrete this liquid when captured and that this liquid is very irritating to the mucous lining of the nose, throat and mouth. In this way some animals have learned to leave the amphibia severely alone. Associated with this is the common belief that the secretions from the skin of toads cause warts. What could be more logical? The skin of the toad is warty, the secretion is irritating, therefore, toads cause warts.

The fact that some species are more conspicuous in wet weather has lead to the popular notion that toads and frogs may be rained down. The spade-footed toads leave their holes and resort to temporary pools during the heavy rains of spring. Young toads leave their pools in enormous numbers after transforming from tadpoles and are very conspicuous during rainy weather. What is more natural than to assume that they rained down?

Many of the salamanders have long, loosely-jointed tails which easily break off when these animals are roughly handled. This has lead to the common superstition that these tails grow back on the animals later. Nothing could be farther from the truth than this. The fact that mutilated amphibians later regenerate a new tail is of course, true, but this is an entirely different process from the broken parts growing together.

CHAPTER V.

THE FISHES AND FISHERIES INDUSTRY.

(Class Pisces.)

- Classification
- The Chief Values of Fish to Man
- Food Fishes
  - Food value
  - Some important fresh water fishes
  - Some anadromous food fishes
  - Some marine food fishes of the Atlantic Coast
  - The more important food fishes of the Pacific Coast
  - How fish are caught
  - How fish are prepared for the market
  - Fish as pest destroyers
- Fish Culture
  - Object
  - Methods
  - Economic importance
    - Number of eggs hatched
- Some Interesting Egg-laying Habits
- Some Curious Fish

CLASSIFICATION.

If all the typically aquatic vertebrates are placed in the class Pisces (Fig. 75), the class may be defined as aquatic vertebrates with fins and gills and the body covered with scales. The fins aid in locomotion. Respiration is carried on through the gills and the body is protected by the scales. The class may be divided into three sub-classes: the sharks (Elasmobranchii), the true fishes (Teleostomi) and the lung fishes (Dipnoi).

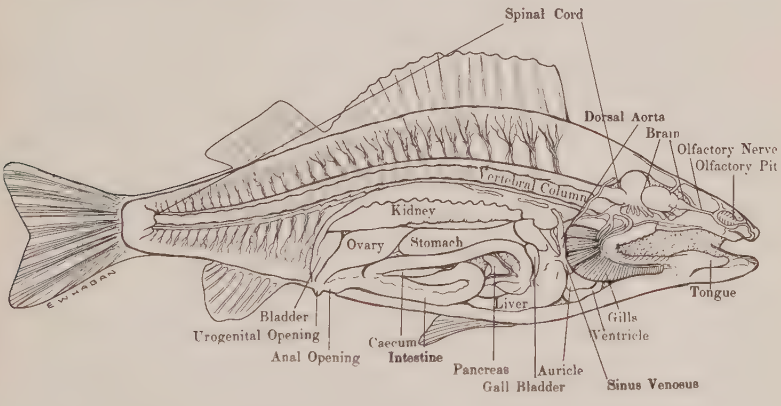

Spinal Cord
Dorsal Aorta
Brain
Olfactory Nerve
Olfactory Pit
Vertebral Column
Kidney
Ovary
Stomach
Tongue
Liver
Gills
Ventricle
Bladder
Urogenital Opening
Caecum
Anal Opening
Intestine
Pancreas
Auricle
Gall Bladder
Sinus Venosus
E W HAGAN

Fig. 75.—A diagram of the general structure of the fish.

The Elasmobranchii include not only the sharks but the rays also. These fishes have a cartilaginous skeleton. The gill slits are exposed, not covered by an operculum. In the sharks the body is spindle-shaped and the gill slits are lateral. In the rays and skates the body is depressed and the gill slits are ventral. The Teleostomi include all the common fishes. The body is spindle-shaped or more or less compressed; usually covered with scales. The gills are covered by a flap or operculum and the skeleton is partially or completely formed of bone.

The Dipnoi forms a very small group of fishes, called lung fishes. The gills are covered by an operculum and they are supplemented by an unpaired or paired lungs. The lung fishes are represented by 3 species in three widely scattered regions of the globe, South America, Central Africa and Australia. They are chiefly interesting because they illustrate a stage in the development of aquatic vertebrates into terrestrial vertebrates.

The following table will give the chief groups of North American fishes and may be used to understand the relationships of the forms of economic importance that are discussed subsequently:

CLASS PISCES.

- *Sub-class* I. *Elasmobranchii.*
  - Order I. Selachii: Sharks and dogfishes.
  - Order II. Batoidea: Skates, rays, electric rays and sawfish.
- *Sub-class* II. *Teleostomi. The true fishes.*
  - Order I. Chondrostei: Cartilaginous ganoid fishes.
    - Family Polyodontidæ—Paddlefish.
    - Family Acipenseridæ—Sturgeon.
  - Order II. Holostei: Scaly ganoid fishes.
    - Family Lepisosteidæ—Gar pikes.
    - Family Amiatidæ—Bowfins.
  - Order III. Teleostei: Bony fishes.
    - Sub-order 1. Ostariophysi.
      - Family Siluridæ—Catfishes.
      - Family Catostomidæ—Suckers, redhorse.
      - Family Cyprinidæ—Minnows, shiners, carp.
    - Sub-order 2. Apodes: Eels.
    - Sub-order 3. Malacopterygii.
      - Family Elopidæ—Tarpons.
      - Family Clupeidæ—Herrings, sardines, shad, alewives, menhaden.
      - Family Engraulidæ—Anchovies.
      - Family Salmonidæ—Salmon, fresh water trouts, whitefish.
    - Sub-order 4. Haplomi.
      - Family Esocidæ—Pikes, pickerels, muskallunges.
      - Family Poeciliidæ—Top-minnows, killifish.

- Sub-order 5. Synentognathi.
  - Family Hemirhamphidæ—Halfbeak.
  - Family Exocœtidæ—Flying fish.
- Sub-order 6. Catosteomi.
  - Family Syngnathidæ—Pipefishes, sea-horse.
  - Family Gasterosteidæ—Sticklebacks.
- Sub-order 7. Percesoces.
  - Family Atherinidæ—Smelts, silversides.
  - Family Mugilidæ—Mullets.
- Sub-order 8. Anacanthini.
  - Family Gadidæ—Cods.
- Sub-order 9. Acanthopterygii—Spiny-rayed fishes.
  - Family Scombridæ—Mackerels, tunas.
  - Family Xiphiidæ—Swordfish.
  - Family Carangidæ—Pompanoes.
  - Family Pomatomidæ—Bluefishes.
  - Family Stromateidæ—Butterfishes.
  - Family Centrarchidæ—Fresh water basses, sunfishes, bluegills.
  - Family Percidæ—Pikes, perch, darters.
  - Family Serranidæ—Sea basses.
  - Family Hæmulidæ—Grunts.
  - Family Lutianidæ—Snappers.
  - Family Sparidæ—Sheepshead.
  - Family Sciænidæ—Drums, sea trout.
  - Family Echeneididæ—Remoras.
  - Family Pleuronectidæ—Flounders.
  - Family Soleidæ—Soles.
- Sub-order 10. Pediculati.
  - Family Lophiidæ—Anglers.
- Sub-order 11. Plectognathi.
  - Family Balistidæ—Triggerfish.
  - Family Monacanthidæ—Filefish.
  - Family Ostraciidæ—Trunkfish.
  - Family Tetraodontidæ—Swellfish, puffers.
  - Family Diodontidæ—Porcupine fish.
  - Family Molidæ—Marine sunfish.

THE CHIEF VALUES OF FISH TO MAN.

Fish are economically of great importance to man. They furnish large amounts of food, oil and fish meal for feed or fertilizer. Some are highly valued for sport while others furnish products of considerable value.

Food.—Many fish have been esteemed for their fine flavor since earliest times. Others because of their abundance and cheapness are consumed in large amounts. As the population of a country becomes more dense and as land values increase people turn more and more to fish as a source of food.

Oil.—A number of fish are caught chiefly because they furnish a ready source of oil. Cod-liver oil is especially valuable because it contains an abundance of vitamin D, which is a preventive for rickets.

Fish Scrap.—The flesh of the fish after the oil has been expressed is known as fish scrap. Fish scrap has been used for fertilizer for a long time. More recently the value of fish scrap as a cheap source of protein feed for animals has been appreciated. The scrap for this purpose is ground into a fine meal and is then known as fish meal. Fish meal is used for feeding dairy cattle, and hogs especially.

Hides.—Experiments are being conducted in the use of the hides of sharks for making leather. Present indications are that these animals will furnish hides that can be tanned into leather of good grades.

Pest Destroyers.—The top-minnow is sometimes called mosquito fish because its principal food is the larvæ of mosquitoes. This little fish has been introduced into many ponds and swamps that could not be drained successfully and has proven to be an efficient method of controlling mosquitoes if conditions for the reproduction of the fish are favorable. The reproduction of this fish is interesting as it brings forth living young. It is presumed that there are several broods produced each year, each brood consisting of from 12 to 24 fish.

Artificial Pearls.—The silvery coating on the scales of certain fishes can be used to make artificial pearls. This material is usually known as pearl essence. The silvery coating is separated from the scales in an ammonia solution, and then filtered out. Thin glass beads are coated with the pearl essence which is backed with wax.

Sport.—While it is fairly easy to compute the total number of pounds of fish caught for food or other purposes, and to estimate the value of each kind, it is an entirely different matter to attempt to calculate the value of fishing as a sport. There are so many elements that enter into our calculations that cannot be measured by any known methods. Who can measure the joy of preparation be it selecting the necessary flies, balancing gray hackle against red, or digging angle worms in the garden? Who can measure the joy of anticipation that comes from one more chance at the big fellow that lies in the pool at the foot of the rapids? How is anyone to measure the value of long dreamy hours spent in a boat on a quiet lake; of strenuous hours following some clear mountain stream for trout; of days in the pounding surf fishing for blackfish, or the thrill that comes from the strike of a 5-pound bass? Only your true fisherman can weigh the value of all these things and everyone is familiar with the proverbial accuracy of the fisherman's scales!

For most fishermen a certain amount of gameness is required of a fish for it to be classified as a game-fish. The black bass, *Micropterus spp.* (Fig. 76), muskallunge, *Esox masquinongy*, and the mountain trout, *Salvelinus fontinalis* (Fig. 77), stand out among the fresh water fishes. The tarpon, *Tarpon atlanticus*, the tuna, *Thunnus thynnus*, the Spanish mackerel, *Scomberomorus maculatus* (Fig. 78) and the

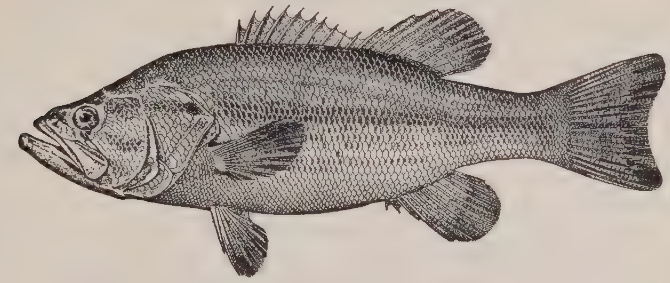


FIG. 76.—Large-mouthed black bass. *Micropterus salmoides.* (After Smith in "Fishes of North Carolina.")

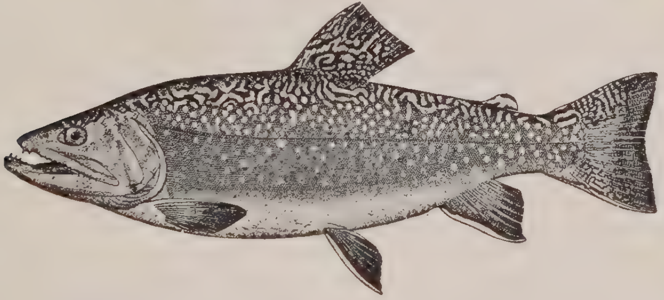


FIG. 77.—Brook trout. *Salvelinus fontinalis.* (After Smith in "Fishes of North Carolina.")

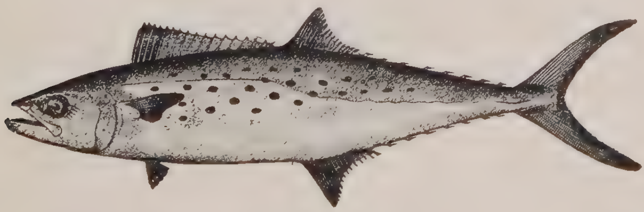


FIG. 78.—Spanish mackerel. *Scomberomorus maculatus.* (After Smith in "Fishes of North Carolina.")

bluefish, *Pomatomus saltatrix* (Fig. 79), among marine forms. When one contemplates the catching of a 250-pound tuna with a rod weighing 12 ounces after playing the fish for ten hours, he has some conception of the skill and patience required in game fishing. However, many people get a great deal of sport out of fishing with hook and line for ordinary fish. In this list belong the sunfish, the yellow perch, the crappie, the rock bass and many others.

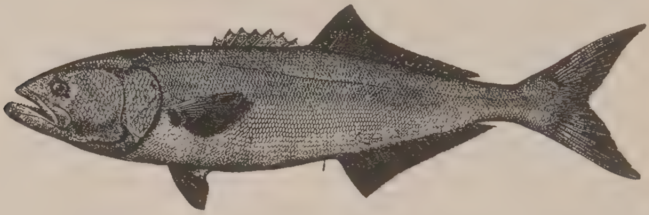


Fig. 79.—Bluefish. *Pomatomus saltatrix.* (After Smith in "Fishes of North Carolina.")

FOOD FISHES.

The following discussion includes some of the more important food fishes of North America together with a discussion of methods of preparing them for market.

Food Value.—The commercial value of a fish seems to be largely dependent upon popular fancy. Formerly the tuna was discarded as of no value, today it is esteemed for its fine flavor. The important factors in determining the value of food fishes seem to be size, abundance, flavor, oiliness and number of bones. Any fish can overcome a deficiency in one of these points if it has other highly desirable qualities. Thus, the shad is excessively bony but this deficiency is overcome by the fine flavor. The sardines and smelts are too small to be considered but their abundance overcomes this deficiency.

Some Fresh Water Food Fishes.—The fresh waters of North America furnish a considerable supply of food fishes. This is especially true of the Great Lakes and the larger rivers, although the amount of food fishes taken from fresh water is never proportional to the amount taken from the sea. In the list of fresh water fishes of importance as food fishes are such familiar forms as the whitefish, the lake trout, the white perch, catfishes, lake herring or ciscoes, pike perch, carp, buffalo fish, fresh water sheepshead, yellow perch and suckers.

The whitefish, *Coregonus clupeiformis*, is a slender, spindle-shaped fish with an average weight of 4 or 5 pounds. It is found in all the Great Lakes but has been so extensively fished in some of these lakes that it is not as common as formerly. The principal fisheries are found in Lake Michigan and Lake Huron. It is taken in gill nets in the shallow waters, where it comes to spawn in the spring. According to the latest figures available, about 4,000,000 pounds are taken each year with a value of $750,000. Among epicureans this fish is supposed to rank second only to the shad.

The lake trout, *Cristivomer namaycush*, is also an inhabitant of the Great Lakes. It is closely related to the brook trout and the rainbow trout but averages much larger, from 15 to 20 pounds. The principal fisheries are found in Lake Superior, Lake Michigan and Lake Huron.

The nets for these fish are usually set at great depths, 300 to 500 feet, and are usually strung together to make a net several miles long. In the average season about 14,000,000 pounds of lake trout are taken, with a value of about $1,500,000.

The fresh water catfishes, *Family Siluridæ*, are elongate fishes with smooth, scaleless skins and elongate barbels on the upper and lower jaws. Both the dorsal and pectoral fins are provided with strong spines which can inflict severe wounds if the fish is handled carelessly. There are a number of species of catfish in North American waters. Some of them seem to be of fine flavor, while others are decidedly inferior. As a general thing they are not much esteemed in the markets as they are very repulsive to some people. Nevertheless, about 9,000,000 pounds are taken each year, with a value of about $800,000. Most of the commercial fisheries are located in Louisiana, Arkansas, Illinois and Lake Erie.

The lake herrings or ciscoes, *Leucichthys spp.*, are small fish with elongate bodies. They are closely related to the whitefish, but their flesh is inferior to the whitefish. They are the most important fresh water fish at the present time. About 35,000,000 pounds, with a value of nearly $1,500,000, are taken each year. About one-half of this amount comes from Lake Erie, but Lake Huron, Lake Michigan and Lake Superior furnish large amounts.

The pike perches, *Stizostedion vitreum*, are next to the ciscoes, the most important of the lake fishes; about 24,000,000 pounds are sent to the markets each year with a value of $1,500,000. These come principally from Lake Erie and Lake Huron. They are taken in pound and gill nets during the spring and summer. In the winter they are speared through small holes in the ice. The pike perches are long, slender fishes, the larger ones attaining a length of 3 feet or more and a weight of 25 to 30 pounds.

The carp, *Cyprinus carpio* (Fig. 80), is a native of China. It was introduced into Europe three or four hundred years ago and then about 1870 it was introduced into this country. It was intended primarily for small lakes and fish ponds, but it soon escaped and is now found throughout the lakes, ponds and streams of this country. The carp is a heavy-bodied fish, usually with large scales, sometimes nearly scaleless. The maximum size is about 50 pounds. The flesh is rather coarse, and as the fish usually lives on muddy bottoms, the flavor of the flesh is often poor. Nevertheless, there is a demand for this fish, especially in the cities with large populations of Germans and people from other middle European countries. In the average year about 26,000,000 pounds are sent to market from Illinois, Iowa, Wisconsin, Minnesota and Ohio. This fish has an annual value of more than $1,000,000.

The buffalo fish, *Ictiobus cyprinella*, is closely related to the carp and resembles it in a general way. The flesh is coarse and bony and of very poor quality. Yet nearly 17,000,000 pounds worth about $1,000,000 are caught each year and sent to the markets. This fish is distributed in all the larger streams in the Mississippi Valley, and the principal commercial fisheries located in Louisiana and Mississippi.

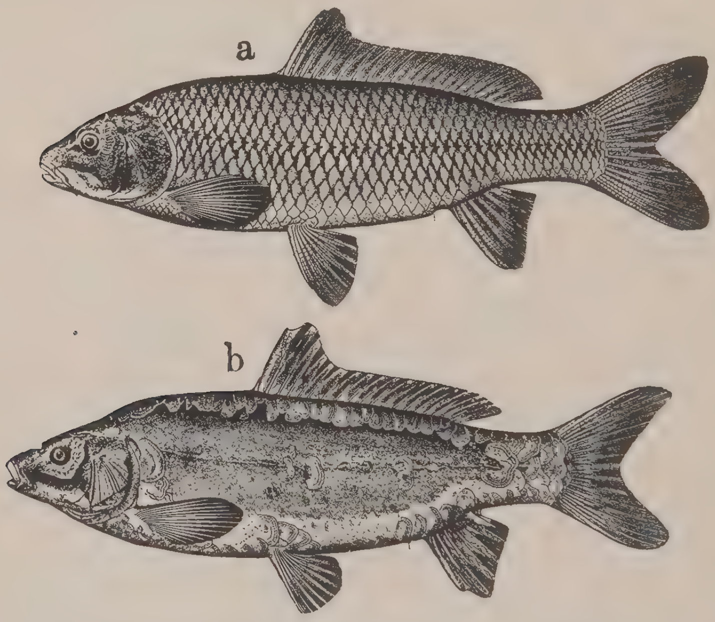


Fig. 80.—*a*, scale carp. *Cyprinus carpio.* *b*, leather carp. *Cyprinus carpio.* (After Smith in "Fishes of North Carolina.")

The suckers, *Family Catostomidæ* (Fig. 81), are elongate, slender, fresh water fish with nearly circular ventral mouths. They abound in most of the streams and ponds of this country. About 5,000,000 pounds are taken each year, chiefly in Lake Erie, Lake Huron and Lake Michigan. Their flesh is of poor quality, however, and they are excessively bony.

The yellow perch, *Perca flavescens* (Fig. 82), is an abundant and familiar fresh water fish. It is a favorite with the bent-pin fisherman, as it will bite almost any kind of bait. It is small in size, averaging about 1 pound. It is olive-green above, yellow below with several broad dark bands. The flesh is fine and well flavored. About 5,000,000 pounds are taken each year with a value of about $300,000.

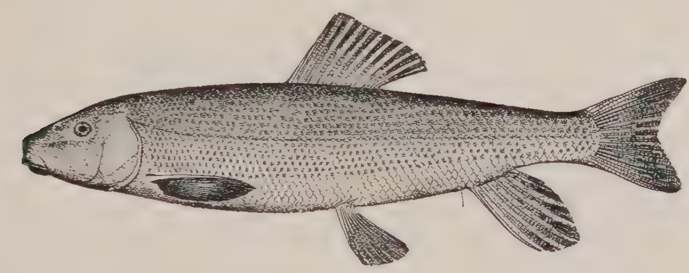


Fig. 81.—White sucker. *Catostomus commersonii.* (After Smith in "Fishes of North Carolina.")

Some Anadromous Food Fishes.—A number of fishes have the habit of ascending fresh water streams from the sea for the purpose of spawning. These fishes are called anadromous fishes. Many of the anadromous fishes are very important food fishes; for example, the salmons, the shad, the alewife and the striped bass.

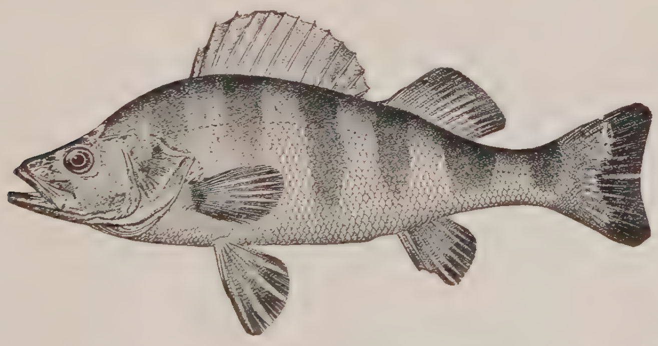


Fig. 82.—Yellow perch. *Perca flavescens.* (After Smith in "Fishes of North Carolina.")

Five species of salmon, *Salmo spp.* (Fig. 83), are known from the Pacific Coast. They constitute a well-known group of food fishes. These live along the coast in the bays and sounds for most of the year. Then early in the spring they run up the rivers to the head waters to spawn. After the females spawn and the males fertilize the eggs the adults die. The young fry descend the streams to salt water, where they reach maturity, and repeat the run. During the spring run salmon are taken by nearly every method of catching fish known to man. They are also sent to the market in nearly all the ways known to man. The majority of the fish are canned, but some are sent fresh, some are frozen, some are pickled, some are salted and some are smoked. The annual catch is estimated at 100,000,000 pounds with a value of about $17,000,000.

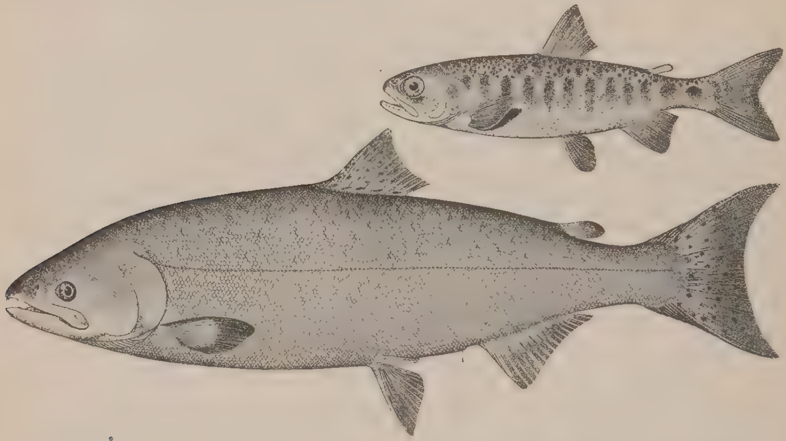


FIG. 83.—Salmon. *Oncorhynchus tschawytscha.* (From U. S. Bureau of Fisheries.)

The shad, *Alosa sapidissima* (Fig. 84), and the run of the shad is as familiar to the people of the Atlantic Seaboard as the run of the salmon is on the Pacific Coast. The shad is a fairly large fish, the females or roe shad averaging 4 to 5 pounds and the males or buck about 3 pounds. The shad is considered one of the finest American food fishes. The flesh is fine, somewhat oily and the fish is excessively bony, but the fine flavor outweighs this deficiency. The average catch is nearly 10,000,000 pounds with a value of nearly

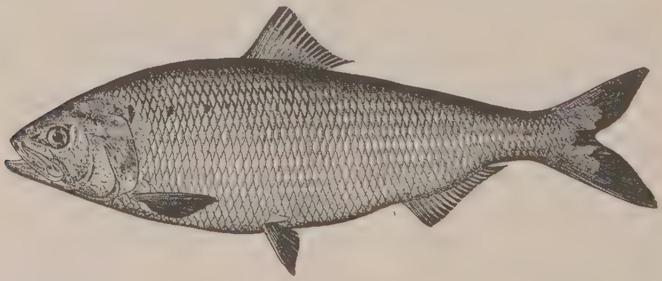


FIG. 84.—Shad. *Alosa sapidissima.* (After Smith in "Fishes of North Carolina.")

$2,500,000. These are taken principally in the rivers and sounds of North Carolina and in the Potomac River and Chesapeake Bay.

The alewife or branch herring, *Pomolobus pseudoharengus,* is closely related to the shad. It is much smaller, however, averaging less than ½ pound. The annual catch is something like 10,000,000 pounds, and they are taken in all the larger streams flowing into the Atlantic Ocean. Seines, pound nets and gill nets are all used in the capture of these fish and reports of 500,000 branch herring being taken at one haul of the seine are not uncommon.

Some Marine Food Fishes of the Atlantic Coast.—The three most important fishes of the Atlantic Coast are the haddock, the cod and the herring, although the mullets, the flounders, the croaker and the common mackerel are of only slightly lesser importance. In addition, the pollock, the Spanish mackerel, the hakes, the bluefish, the cero, the halibut, the swordfish, the whiting, the drum and the groupers add materially to the food supply of this country.

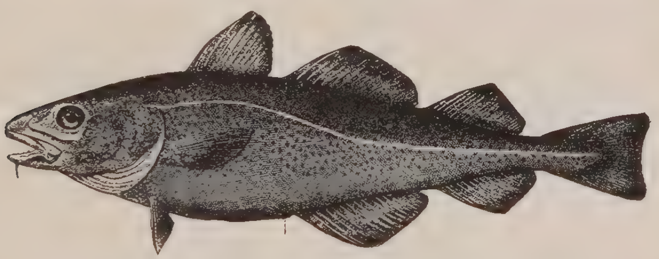


FIG. 85.—Cod. *Gadus callarias.* (After Smith in "Fishes of North Carolina.")

The cod, *Gadus callarias* (Fig. 85), is an inhabitant of the colder waters of the Northern Hemisphere, but the fisheries on the Atlantic Coast are many times as valuable as those on the Pacific Coast. Because of its abundance the cod has long been a favorite food fish. The annual catch in the United States is about 90,000,000 pounds with a value of about $3,000,000. In this respect it is exceeded by its close relative, the haddock, *Melanogrammus æglefinus,* which has an annual catch of nearly 100,000,000 pounds, but this fish is not considered as valuable as the cod, bringing the fisherman only $2,500,000. The pollock, *Pollachius virens,* is another important food fish of this same group. There is an annual catch of about 8,000,000 pounds. All three of these fish have the same general appearance. The body is elongate spindle-shaped. There are three dorsal fins and the lower jaw is provided with a single barbel. The average cod weighs about 10 pounds, the average haddock about 3 or 4 pounds and the average pollock about 10 to 12 pounds. The cod and the haddock live at moderate depths, but the pollock is largely a surface feeder. Large amounts of these fishes are consumed as fresh and frozen fish, but a goodly proportion is marketed as salt fish. The cod and haddock are largely taken by lines and otter trawls, but the pollock is captured largely by the use of gill nets.

The common herring, *Clupea harengus,* is an inhabitant of both sides of the North Atlantic. They have long been of importance to man because they occur in enormous schools and may be taken with comparative ease. The herring is taken in the United States, principally in the waters of Maine and Massachusetts. These fish are taken chiefly in pound nets, weir nets and trap nets. The annual catch in the United States amounts to about 60,000,000 pounds valued at $500,000. Herrings are sent to market fresh, salted and smoked.

The mullets, *Family Mugilidæ* (Fig. 86), include stout fishes with head and body covered with coarse scales and with the head flattened. The mullets swim in large schools at the surface of the ocean. They are taken principally by seines and gill nets. The annual catch is about 40,000,000 pounds with a value of about $1,500,000.

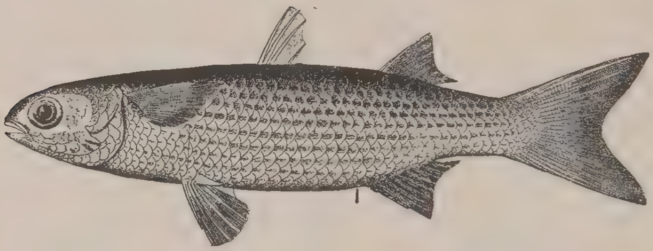


Fig. 86.—White mullet. *Mugil curema.* (After Smith in "Fishes of North Carolina.")

The flat fish are bottom feeders, with the head twisted so that both eyes lie on the same side of the head, which is the right side in some species and the left side in others. The fry of the flat fish swim as our other fish swim, with an eye on each side of the head. As development proceeds the fish settles to the one side or the other and the eye that would be on the bottom side migrates to the top side of the head. Our smaller species of flat fish are generally known as flounders. Those sent to market average from 3 to 5 pounds. Most of these are taken in otter trawls, although a few are taken on lines and a few are speared in the shallow water at night, using a flare to light up the bottom. The flesh of the flounder is firm and white and of good flavor, with few bones. About 30,000,000 pounds are caught each year, with a value of about $1,250,000. The halibut, *Hippoglossus hippoglossus,* is a large flat fish, weighing as much as 400 pounds. It occurs in shallow water along the shore as well as in deeper water. About 4,000,000 pounds, valued at $800,000, are taken each year, being relatively one of the most valuable fishes taken in New England waters. Practically all the catch comes from Massachusetts, and most of the fish are taken on lines.

The croaker, *Micropogon undulatus* (Fig. 87), is a rather stout, elongate fish that is extensively taken along the South Atlantic Coast. It receives its name from the peculiar grunting noise that it makes when caught. The flesh is rather coarse and not especially fine flavored, nevertheless the annual catch is about 30,000,000 pounds with a value of about $750,000. The croaker is taken in seines, gill nets and pound nets and sent to the market fresh, although a small amount is salted each year. The mackerels constitute a group of important food fishes, including the common mackerel, *Scomber scombrus*, of the North Atlantic, the Spanish mackerel, *Scomberomorus maculatus* (Fig. 78), of the South Atlantic and Gulf of Mexico, and the cero, *Scomberomorus spp.*, of the South Atlantic. The body of the mackerel is elongate, spindle-shaped with head pointed and tail tapering. The skin is smooth and almost scaleless. The common mackerel is the most valuable of the three, with a total annual catch of more than 25,000,000 pounds and a value of about $1,500,000. They are taken principally in Maine and Massachusetts waters and chiefly in purse seines and pound nets. About 1,000,000 pounds are salted each year and the rest are sent to the market fresh. The Spanish mackerel is taken chiefly in Florida and Alabama, and it averages from 5 to 10 pounds. It is justly considered one of the finest of food fishes. The toal annual catch is about 7,000,000 pounds with a value of $500,000.

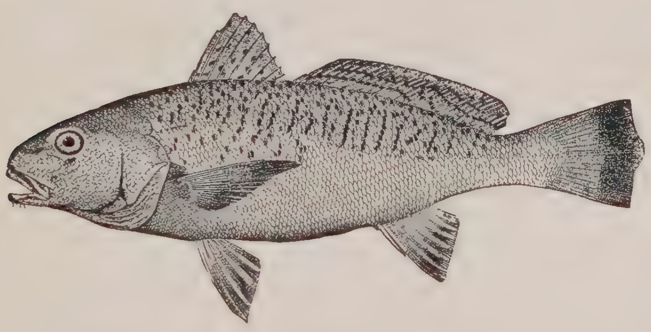


FIG. 87.—Croaker. *Micropogon undulatus.* (After Smith in "Fishes of North Carolina.")

The More Important Marine Food Fishes of the Pacific Coast.—The most important food fish of the Pacific Coast from the standpoint of pounds caught is the pilchard or California sardine. About 160,000,000 pounds are caught each year, and next in importance are the tuna and halibut, with about 25,000,000. Of these, the halibut is the most valuable and the pilchard the least valuable. The pilchard and the tuna are usually canned, but the halibut is frozen or sent to the market fresh.

A TABLE OF THE PRINCIPAL FOOD FISHES OF THE UNITED STATES APPROXIMATED FROM THE VARIOUS REPORTS OF THE BUREAU OF FISHERIES.

Atlantic Ocean and Gulf of Mexico.

Fish.	Approximate number, pounds.	Approximate first value.	Principal fishing grounds.
Alewife	10,000,000	$190,000	N. C., Fla., Maine, Mass.
Bluefish	2,000,000	200,000	N. C., Fla.
Butterfish	13,000,000	90,000	R. I., Mass.
Catfish	1,000,000	45,000	
Cero	2,000,000	160,000	Fla.
Croaker	27,000,000	765,000	Md., Va., N. C.
Cod.	90,000,000	3,000,000	Maine, Mass., R. I., Conn.
Cusk	4,000,000	80,000	Maine, Mass.
Drum	4,000,000	230,000	Fla., La., Tex.
Flounders	30,000,000	1,340,000	Maine, R. I., Conn.
Groupers	5,000,000	120,000	Fla., Ala.
Haddock	94,000,000	2,655,000	Maine, Mass.
Halibut	4,000,000	790,000	Mass.
Herring	57,000,000	560,000	Maine, Mass.
Hake	18,000,000	300,000	Maine, Mass.
Mackerel	25,000,000	1,430,000	Maine, Mass., R. I.
Mullet	38,000,000	1,490,000	N. C., Fla., Miss.
Pollock	8,000,000	220,000	Maine, Mass.
Scup	1,000,000	70,000	R. I.
Shad	10,000,000	2,355,000	Md., Va., N. C., Fla.
Spanish mackerel	7,000,000	520,000	Fla., Ala.
Sheepshead	1,000,000	61,000	Fla.
Snapper red	12,000,000	865,000	Fla., Tex.
Swordfish	3,000,000	520,000	Maine, Mass.
Squeteague	33,000,000	1,500,000	Md., Va., N. C., Fla., La., Tex.
Whiting	8,000,000	84,000	Mass., R. I.

Fresh Water Fishes—Great Lakes and Mississippi Valley.

Buffalo fish	17,000,000	$1,000,000	Ill., Iowa, Ark., Miss., La.
Carp	26,000,000	1,200,000	Minn., Wis., Lake Erie, Ill., Iowa
Catfish	8,000,000	700,000	Ark., La., Iowa, Ill.
Ciscoes	35,000,000	1,400,000	Lakes Superior, Michigan, Huron Erie
Paddlefish	1,000,000	130,000	Miss., La., Ark.
Pike perch	24,000,000	1,500,000	Lakes Huron, Erie
Sheepshead	7,500,000	300,000	Ark., Ill., La., Wis., Lake Erie
Suckers	5,000,000	250,000	Lakes Michigan, Huron, Erie
Lake trout	14,000,000	1,500,000	Lakes Superior, Huron, Michigan
White bass	1,000,000	50,000	Lake Erie
Whitefish	4,000,000	750,000	Lakes Michigan, Erie, Huron
Yellow perch	5,000,000	300,000	Lakes Michigan, Erie, Huron

Pacific Coast States.

Fish.	Approximate number, pounds.	Approximate first value.	Principal fishing grounds.
Barracuda	6,000,000	$430,000	Calif.
Bonito	11,000,000	575,000	Calif.
Cod.	5,000,000	250,000	Wash.
Flounder	5,000,000	475,000	Calif.
Hallibut	25,000,000	3,300,000	Wash., Ore.
Mackerel	3,500,000	150,000	Calif.
Pilchard	159,000,000	700,000	Calif.
Rockfish	5,000,000	250,000	Calif.
Salmon	106,000,000	7,200,000	Wash., Ore., Calif.
Sea bass	4,000,000	250,000	Calif.
Smelt	2,000,000	170,000	Wash., Calif.
Sole	7,000,000	215,000	Calif.
Tuna	25,000,000	1,350,000	Calif.
Yellowtail	3,000,000	200,000	Calif.

How Fish Are Caught.—Man has devised many different ways of catching fish from spears and gigs to hooks, traps and nets of various kinds. A few of the more important methods used by commercial fishermen will be discussed. Nets are of two general types, set nets and seines. Set nets are of a number of different types. Two of the most important types are the gill nets and the pound nets. In the gill nets the meshes are loosely woven and of such size as to allow the average fish to get its head through but not its body. The flaps or opercula on each side of the head then hold the fish until removed by the fisherman. The pound net consists of a leader, wings, a heart and a pound. The leader usually starts near the shore and leads the fish traveling along the shore toward the heart. The wings direct the fish toward the heart. The heart opens into the pound by a small funnel-shaped opening. The pound is a small enclosure, usually with sides and bottom of netting, in which the fish remain until removed by the fisherman. Seines are nets used to surround schools of fish. They are of two general types, haul seines and purse seines. In the haul seines a school of fish near shore is surrounded and the two ends are gradually hauled up on the shore or into shallow water and the fish removed. Purse seines are constructed to surround a school of fish with the bottom provided with a line which may be drawn up, thus closing the seine like a purse.

A weir is quite similar to a pound net, but is usually constructed of stakes interwoven with brush or of planks. The essential parts are long leads which guide the fish into a large enclosure and from the large enclosure they go into a small enclosure, where they remain until removed by the fisherman.

Lines are extensively used in catching some fish. In commercial fishing this consists of a main line of greater or less length to which are attached other lines with baited hooks.

The trawl is a bag net fitted with a wide mouth which is kept open by a beam and gradually narrowed toward the end. This is dragged over the bottom and is an excellent method of catching bottom-feeding fish.

How Fish Are Prepared for Market.—The bulk of the fish sent to market are known as fresh fish. Formerly, the fish were caught near the market and no special care was taken in their preparation, as they were used soon after they were caught. As the cities increased in size, the nearer fishing grounds were exhausted. The fish were caught at some distance from market and required special preparation and handling The principal method used at the present time is to place the fish in boxes with ice if the haul is not too long, or to ship them in refrigerator cars on the long hauls. A better fish can be placed on the market, however, if they are cleaned by removing the entrails soon after the fish is caught and then icing. This practice is growing in favor especially in the larger markets. Since the catch of fish is a very variable quantity, the freezing of the fish in refrigeration plants when the market is oversupplied, and holding the frozen fish until there is a demand, is a growing practice. Only a very small proportion of our fish are sent to market alive in tank cars. The chief difficulty is to supply a sufficient amount of air to carry the fish through. This method has been used with success for the carp.

Salting fish has long been a common practice of preparing fish. Some fish are put up in brine and others are salted dry. The former method is known as pickling and is a favorite method of handling mackerel, herring and alewife. Dry salting is used chiefly for the cod. In this method the fish are cleaned and salted and then placed on racks to dry. The fish are protected from the sun and rain by canvas or shingle roofs. Smoking fish is a continuation of the pickling process as the fish must first be pickled, then most of the salt soaked out and then smoked. The principal fish smoked in the United States are the common herring, the halibut and the salmon.

Canning is a favorite method of preparing salmon, sardines, pilchards and tuna for the market. The fish are first cleaned, then placed in cans and cooked under pressure at a high temperature.

SOME INTERESTING EGG-LAYING HABITS.

Most fish simply lay their eggs in the open water and the males pour the milt over the eggs. A few fish, however, have interesting breeding habits. In some fish, for example, the dog-fish sharks, *Squalus acanthias*, the eggs are fertilized internally and are retained within the mother and the young born alive. Some fish, like the sunfishes, hollow out shallow nests on the bottom in the shallow water. The female lays the eggs. The eggs are guarded by the male until they hatch. The nests are often crowded so close together that it is very difficult to understand how any fish could know its own nest.

The stickle-backs, *Family Gasterosteidæ,* which are small, slender, minnow-like fish living in the brackish water along the North Atlantic Coast are famous as nest-builders. The fish are provided with sharp spines on the back, hence the name "stickle-back." The male has a gland which secretes a clear gelatinous substance, which forms threads when it comes in contact with the water. The male fastens these threads to the stems of water plants, and by secreting more and more gradually builds a hollow ball of threads with a hole large enough for the female to pass through and deposit her eggs. The male then fertilizes the eggs and guards them until they hatch.

In the sea cat the eggs are laid on the sand and fertilized by the male. The male then takes the eggs into his mouth and retains them until they hatch. The young remain in the mouth for some time after they hatch and then swim out.

In the pipefish, *Siphostoma spp.*, and the sea-horse, *Hippocampus guttatulus,* the male is provided with a brood pouch at the base of the tail. Eggs are transferred directly from the oviduct of the female to this pouch. After the eggs hatch the fish swim out of the pouch for food, but for a time they use it as a safe retreat and return to the pouch in time of danger.

The annual migration of fish from salt to fresh water to spawn is a familiar phenomenon and hardly needs comment. Man has long taken advantage of these runs to secure fish for food. In fact, many fish that have this habit have been fished almost to the point of extinction. The shad, the striped bass, the smelts and the alewife are familiar fish of this type. On the Pacific Coast there are the well-known salmons, which have the same habit. These anadromous fish, as they are called, will often endure hardships beyond belief in order to reach suitable breeding grounds. The sockeye salmon has been known to make a journey of more than 1000 miles from the ocean in order to lay its eggs in a lake at the headwaters of a stream. After spawning is over the males and females die.

While the migration of anadromous fish from salt to fresh water to spawn is well known, and is actually the basis of some of our most important fisheries, that the reverse process takes place, and that the eel migrates from fresh water to salt water to spawn is commonly denied. Yet this is the case. After becoming nearly full grown in fresh water the eels migrate down the streams to the sea, where the eggs are laid. After the females lay their eggs, and they are fertilized by the males, the adults die. The eggs float on the surface of the sea and hatch into transparent larvæ known as leptocephali. The larvæ have no resemblance to the adult eel. They gradually change to the adult form, and by the time they are 1 or 2 inches long have entered the streams ready for their migration to their feeding-grounds.

SOME CURIOUS FISH.

There are many curious fish in various parts of the world. There is space here, however, for brief notes on a few. The remarkable breeding habits of the sea-horse have already been described. In addition, this is one of the strangest fish in the world. The head is bent at right angles to the body and its long snout gives it a horse-like appearance, hence the name. The body is completely covered with bony plates and the tail is elongate and can be curled around a water plant for support. The pipefishes are closely related to the sea-horses. The head is similar in shape, the body is much elongate and covered with bony plates.

The swordfish, *Xiphias gladius*, has the upper jaw prolonged into a long, flat sword, which is used for offense and defense. Since this fish sometimes reaches a length of 12 feet and a weight of 500 pounds or more with a sword half as long as the body, and since it can swim very rapidly through the water, it can be readily understood that this is a dangerous animal. Formerly swordfish were not thought fit for human food, but now the steaks are considered a very great delicacy.

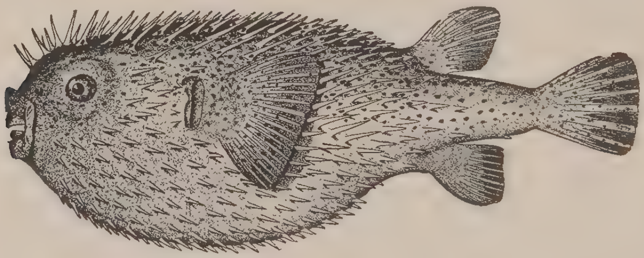


FIG. 88.—Porcupine fish. *Diodon hystrix.* (After Smith in "Fishes of North Carolina.")

The porcupine fish, *Diodon hystrix* (Fig. 88), is a short, rounded fish. The body is thickly set with short spines. This fish can distend the body with air or water. The dead bodies of this fish are sometimes blown up with air and then dried. These objects are sold as curios.

The swell fishes are similar to the porcupine fishes in their ability to inflate the body like a balloon. This is done by taking air or water into a separate sac in the abdominal cavity.

The flying fish are small, elongate fish with greatly developed pectoral fins. According to Dr. Jordan, the flying fishes live in the open sea, swimming in large schools. They will "fly" a distance of from a few rods to more than $\frac{1}{8}$ mile, rarely rising more than 3 or 4 feet above the surface. Their movements in the water are extremely rapid; the sole source of motive power is the action of the strong tail while in the water. No force is acquired while the fish is in the air. On rising from the water, the movements of the tail are continued until the whole body is out of the water. While the tail is in motion the pectorals seem to be in a state of rapid vibration, but this is apparent only, due to the resistance of the air to the motions of the animal. While the tail is in the water the ventrals are folded. When the action of the tail ceases the pectorals and ventrals are spread and held at rest. They are not used as wings, but act rather as parachutes to hold the body in the air. When the fish begins to fall the tail touches the water, when its motion again begins, and with it the apparent motion of the pectorals. It is able thus to resume its flight, which it finishes finally with a splash. While in the air it resembles a large dragonfly. The motion is very swift, at first in a straight line, but later deflected into a curve. The motion has no relation to the direction of the wind. When a vessel is passing through a school of these

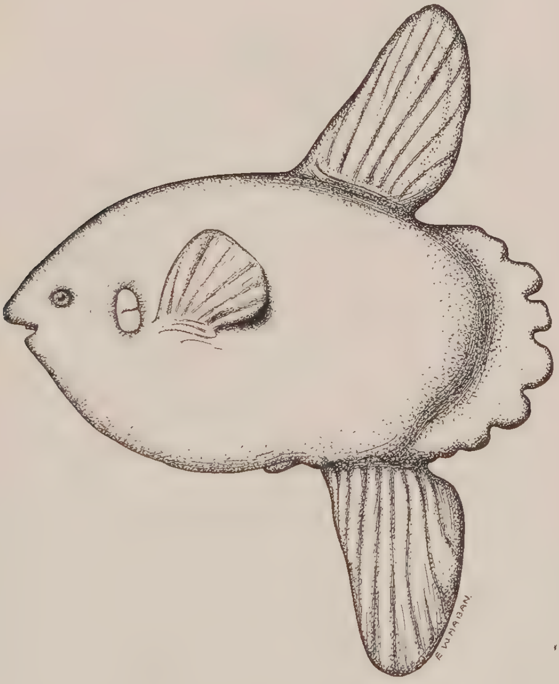


FIG. 89.—Headfish. *Mola mola.*

fishes they spring up before it, moving in all directions, as grasshoppers in a meadow.

The headfish, *Mola mola* (Fig. 89), is a very large fish, frequently attaining a weight of 1000 to 1500 pounds. The figure will serve to give a notion of the shape of this fish better than any description. Its large size and peculiar shape make it an object of much interest wherever it is taken. It inhabits all the oceans and as it is a slow-moving, surface-swimming fish it is quite frequently captured.

The shark sucker, *Remora brachyptera*, is an elongate, spindle-shaped fish, often 30 inches or more in length. The anterior-dorsal fin is modified into a peculiar sucking disk, which enables this fish to attach itself to sharks or other large fish and get a free ride. The ancients believed that these small fish could becalm a boat by attaching themselves to the side of the boat. This belief has persisted in many parts of the world.

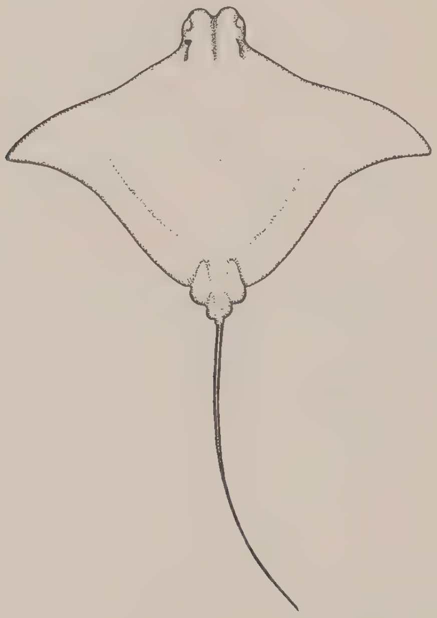


Fig. 90.—Cow-nosed ray. *Raia spp.*

Electric fish are fish that have peculiar modified muscles that are capable of generating and storing electricity. This electricity may be used for securing prey or for defense. Some of the larger electric fish can give a shock that is disconcerting to a large animal. The electric ray or torpedo and the electric toad are quite common along our coast. While in Brazil they have an electric eel, which is said to be able to give the most powerful shock of any of the electric fish.

Among the sharks, the hammer-head, *Sphyrna zygæna*, is the most peculiar. The head is drawn out into two lateral projections which carry the eyes and the nostrils. This is a shark of the warmer oceans, but it is occasionally found on both the Atlantic and Pacific Coasts.

The skates and rays, *Raia spp.* (Fig. 90), are much-flattened sharks. One of the interesting forms is the sawfish. It is said to reach a maximum length of 20 feet, with the saw about one-third as long as the rest of the body. The saw is broad and sword-like with a row of about thirty teeth along each side. This is a weapon of defense, which the fish uses by curling the body and then striking sidewise. It is said to be very destructive to nets if caught.

The sting-ray or stingaree, *Stoasodon narinari*, is a ray with a very long, flexible tail which it uses as a weapon of defense. The tail is very sharp at the tip and can inflict a painful wound.

The Deep-sea Fishes. –The abysmal depths of the ocean contain many strange animals, but the strangest of them all are the deep-sea fishes. About 1000 different kinds of deep-sea fishes are known. Some of these fish have been taken from 1 to 3 miles below the surface. Naturally, at such great depths under such tremendous pressure, in perpetual night, at a temperature not far from freezing, we would ·expect to find many curious fish. Practically all are provided with phosphorescent organs, sometimes the whole fish glows with a pale light. Sometimes the head is provided with a long projection which has a luminous bulb at the tip. Sometimes there are little round spots in a single or double row down the side like the portholes in a fully-lighted ship. Most of these forms are carnivorous. They are usually provided with large mouths and sharp teeth. Practically all deep-sea fish are small in size, being only a few inches long.

FISH CULTURE.

The object of fish culture is to carry the young fish through the most dangerous period of their life just after hatching and to increase the supply of food and game fishes by this method. The essential steps in the process are collecting the males and females, stripping, fertilizing the eggs, hatching, rearing and transporting.

Ordinarily ripe, uninjured males and females are collected from the fishermen during the breeding season for the purpose of securing fresh milt and eggs. Sometimes live fish are kept in special holding-pens until they are ripe. The ripe females are stripped of their eggs by pressure applied to the abdomen. If the fish are fully ripe the eggs are easily pressed out. These eggs are collected in pans or trays and the milt from the males, which is also easily pressed out when the males are ripe, is spread over the eggs. Sometimes it is necessary to use the milt from two or more fish to fertilize the eggs of a single female.

Species.	Eggs.	Fry.	Fingerlings.	Total.
Atlantic salmon	. . . . .	1,410,000	12,500	1,422,500
Black-spotted trout	16,802,060	4,776,100	1,584,817	23,162,977
Brook trout	500,000	2,776,469	12,755,628	16,032,097
Buffalo fish	127,400,000	12,562,500	4,261,430	144,223,930
Carp	. . . . .	31,500,000	10,959,465	42,459,465
Catfish	. . . . .	. . . . .	14,310,290	14,310,290
Chinook salmon	7,504,880	2,528,800	42,684,200	52,717,880
Chum salmon	. . . . .	16,051,650	. . . .	16,051,650
Cisco	8,000,000	118,900,000	. . . .	126,900,000
Cod	598,065,000	462,712,000	. . . .	1,060,777,000
Crappie	. . . . .	. . . . .	16,884,251	16,884,251
Fresh water drum	. . . . .	. . . . .	19,590	19,590
Glut herring	. . . . .	92,000,000	. . . .	92,000,000
Grayling	. . . . .	4,877,000	29	4,877,029
Haddock	139,366,000	24,511,000	. . . .	163,877,000
Humpback salmon	. . . . .	10,892,500	. . . .	10,892,700
Lake trout	2,940,000	32,822,613	309,815	36,072,428
Landlocked salmon	81,000	816,621	219,825	1,117,446
Largemouth black bass	. . . . .	1,135,100	1,615,021	2,750,121
Loch Leven trout	8,803,000	. . . . .	784,341	9,587,341
Mackerel	. . . . .	3,517,000	. . . .	3,517,000
Miscellaneous fishes	. . . . .	. . . . .	3,696,495	3,696,495
Pike perch	122,450,000	116,100,000	141,584	238,691,584
Pike and pickerel	. . . . .	. . . . .	709,077	709,077
Pollack	. . . . .	222,890,000	. . . .	222,890,000
Rainbow trout	3,008,754	1,989,500	2,326,485	7,324,739
Rock bass	. . . . .	. . . . .	60,560	60,560
Shad	. . . . .	17,158,671	. . . .	17,158,671
Silver salmon	862,000	10,177,650	3,797,639	14,837,289
Silver trout	. . . . .	. . . . .	100,000	100,000
Smallmouth black bass	. . . . .	545,400	41,927	587,327
Sockeye salmon	3,150,000	28,070,000	3,891,700	35,111,700
Steelhead salmon	604,000	124,580	1,327,184	2,055,764
Sunfish	. . . . .	. . . . .	13,894,947	13,894,947
Warmouth bass	. . . . .	. . . . .	5,370	5,370
White bass	. . . . .	. . . . .	4,425	4,425
Whitefish	340,000	172,630,000	. . . .	172,971,000
Winter flounder	4,667,000	2,637,051,000	. . . .	2,641,718,000
Yellow perch	5,850,000	83,988,800	555,340	90,394,140
Total	1,050,393,694	4,114,514,954	136,953,935	5,301,862,583

After the eggs are fertilized they are transferred to hatching jars. Hatching jars are of a number of different types, but in their essentials they are cylindric, glass jars of about 2-gallon capacity with a water supply run to the bottom of the jar through a tube and an overflow at the top. The water flowing through these jars keeps the eggs in constant motion. As the eggs in each jar hatch they are carried through troughs to what are known as the fry tanks. These young fish are called fry. Sometimes the fry are planted just as soon as they are hatched. Sometimes these young fry are held until the yolk sac has been absorbed. These older fry are better able to take care of themselves when they are planted.

In some cases the eggs are placed in trays instead of jars. The trays have a wire-cloth bottom with the mesh small enough to retain the eggs, yet large enough to permit the fry to fall through as rapidly as they hatch. The trays may then be stacked one on top of another and placed in troughs. These troughs are divided into compartments and the water supply is arranged so that it flows up through the trays. If the fry are to be raised to the next stage, known as fingerlings, they must be placed in special rearing troughs and fed regularly. The usual food consists of finely-ground meat.

The fry or fingerlings are usually placed in milk cans and shipped by express if small lots are to be delivered. If large lots are to be delivered they are usually shipped in special cars with tanks which can be aërated.

The table (page 170) shows the distribution of the various species of fish by the United States Bureau of Fisheries in 1925.

CHAPTER VI.

THE ARTHROPODA IN GENERAL.

(Phylum Arthropoda.)

- The Structure of a Typical Arthropod
- The Classification of the Arthropoda
  - Class Crustacea
  - Class Onychophora
  - Class Myriapoda
  - Class Arachnida
  - Class Insecta
- Class Crustacea
  - The anatomy of the crayfish
  - Some interesting crustacea
  - Crustaceans of economic importance
  - The lobster and lobster fishing
  - The crabs
  - The shrimps

THE STRUCTURE OF A TYPICAL ARTHROPOD.

This is the largest phylum of the animal kingdom. The number of species in this phylum probably outnumbers all the species in the other phyla more than 3 to 1. Most of the members of this extensive group show the same fundamental plan. They have a distinctly segmented body; the segments, tending to amalgamate into two or three distinct regions, such as the head, the thorax and the abdomen. Most of the species have a firm exoskeleton to which the muscles are attached internally. In such forms growth is only possible by shedding the skin; the growth taking place before the exoskeleton is shed and the expansion occurring before the exoskeleton becomes firm again. Jointed appendages are typically present on all segments. These appendages are chiefly locomotory, but have been variously modified as sensory organs, as masticatory organs, as weapons of offense or defense, and as copulatory organs, for example. In many forms the segments have been consolidated, especially in the head region, and in many forms the appendages of certain segments have been lost. The nervous system is highly organized of the general annelid type, with a dorsal or supra-esophageal ganglion or brain, a circum-esophageal ring and a chain of ventral ganglia, with one ganglion for each segment. There has been considerable consolidation and cephalization of the ventral ganglia, and the posterior part of the body may be without ganglia in the more specialized forms. Elaborate sensory organs are usually present. They may be classified as *mechanical sense organs*, those concerned with touch and hearing; *chemical sense organs*, or those concerned with taste and smell; *organs of sight*, both simple and compound eyes; *organs of equilibration*, or those concerned with static and dynamic position. Our knowledge of these organs is based largely on a comparison with those of vertebrates and more especially with human sense organs and may be largely erroneous. The digestive system is complete. The mouth is usually provided with elaborate masticatory organs, sometimes involving three or more appendages, which have been modified for particular types of food. The digestive canal is complete and a distinct stomach is usually developed for the digestion of food. Sometimes accessory pouches or crops are present, the food being stored in these until required. The intestine is usually short. Respiration may be carried on by various types of gills in the aquatic species and by long-branched tubes, called *trachea*, or by elaborate structures, called *book lungs*, in the terrestrial forms. Circulation of the body fluids is provided in most forms by a dorsal heart and an incomplete system of blood vessels. The sexes are separate and development is often accomplished by an elaborate metamorphosis or change of form. Most forms lay eggs, but a few forms are viviparous, producing living young.

THE CLASSIFICATION OF THE ARTHROPODA.

There are four distinct classes of importance in this phylum: The *Crustacea*, or crayfishes, lobsters, crabs, water fleas, etc.; the *Myriapoda*, or centipeds and millipeds; the *Arachnida*, or spiders, mites, ticks, etc.; the *Insecta*, or bugs, flies, beetles, butterflies, moths, bees, ants, wasps. The comparative features of these various classes will be apparent from an examination of the following table. (Page 174).

CLASS CRUSTACEA.

To this class belong the crayfish or crawfish, lobster, crabs, water fleas, pill bugs or sow bugs, barnacles and shrimps. Typically the body is divided into a cephalothorax, *i. e.*, a fused head and thorax and an abdomen, although in some forms the head and thorax are not fused. In the higher forms, like the lobster and crayfish, the number of segments in the body is twenty, as evidenced by the nineteen pairs of appendages and the telson, a modified segment without an appendage.

Anatomy of the Crayfish. The crayfish has been used for a long time as a typical example of the crustacea (Fig. 91). Its anatomy will be discussed briefly.

Appendages.—The appendages of the crayfish may be grouped as indicated in Table II.

TABLE I.—A TABLE COMPARING THE CLASSES OF ARTHROPODA.

Class.	Common names.	Habitat.	Body regions.	Antennæ.	Mouth parts.	Legs.	Respiration.	Wings.
Crustacea:								
Entomostraca	Water fleas	Aquatic, few parasitic	Head, thorax (cephalothorax) abdomen	Two pairs	One pair mandibles; two pairs maxillæ	Two to 60 pairs	Gills	Wanting
Cirripedia	Barnacles	Aquatic, few parasitic		Two pairs	Three	Four pairs	Gills	Wanting.
Malacostraca	Crayfish, lobster, crabs	Chiefly aquatic few terrestrial	Cephalothorax, abdomen	Two pairs	One pair mandibles; two pairs maxillæ, one to five pairs maxillipeds	Usually five or seven pairs	Gills	Wanting.
Myriapoda:								
Diplopoda	Millipeds or thousand legged worms	Terrestrial	Head, trunk	One pair	One pair mandibles, one pair maxillæ	Two pairs to each segment, 28 to 200 or more pairs	Trachea	Wanting.
Chilopoda	Centipeds	Terrestrial	Head, trunk	One pair	One pair mandibles, two pairs maxillæ	One pair to each segment, 15 to 75 or more pairs	Trachea	Wanting.
Arachnida:	Spiders, ticks, mites, scorpions	Terrestrial	Cephalothorax, abdomen	None	One pair chelicera (pedipalps)	Four pairs	Book lungs, trachea	Wanting.
Insecta:								
Apterygogena	Spring tails, etc.	Terrestrial	Head, thorax, abdomen	One pair	One pair mandibles, one pair maxillæ, labium	Three pairs	Trachea	Wanting.
Pterygogena	Grasshoppers, true bugs, beetles, butterflies, flies, bees, etc.	Terrestrial, few aquatic	Head, thorax, abdomen	One pair	One pair mandibles, one pair maxillæ, labium; often greatly modified	Three pairs	Trachea	One or two pairs or wanting.

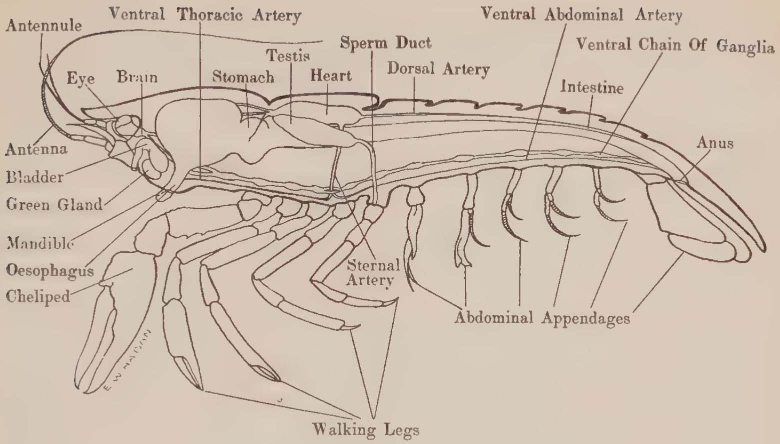

Antennule
Ventral Thoracic Artery
Ventral Abdominal Artery
Sperm Duct
Testis
Ventral Chain Of Ganglia
Eye
Brain
Stomach
Heart
Dorsal Artery
Intestine
Antenna
Anus
Bladder
Green Gland
Mandible
Oesophagus
Cheliped
Sternal Artery
Abdominal Appendages
Walking Legs

FIG. 91.—Diagram of a crayfish.

TABLE II.—A TABLE OF THE APPENDAGES OF THE CRAYFISH.

Body region.	Appendage.	Description.	Function.
Head	Antennule	Biramous many jointed flagellum	Sensory: smell, touch, equilibrium.
	Antenna	A long many jointed flagellum	Sensory: touch.
	Mandible	A heavy base with jointed palpus	Chewing food.
	1st maxilla	A thin leaf-like appendage	No important function.
	2d maxilla	A thin leaf-like appendage	Produces current of water over gills.
Thorax	1st maxilliped	Thin leaf-like base with many jointed filament	Holds food. Sensory: taste
	2d maxilliped	Similar to first maxilliped	Holds food. Sensory: taste
	3d maxilliped	Similar to first maxilliped	Holds food. Sensory: taste
	Cheliped or pincer	Heavy jointed appendage with powerful pincers	Fighting. Holding prey.
	1st walking leg	Jointed leg with small pincers	Walking.
	2d walking leg	Jointed leg with small pincers	Walking.
	3d walking leg	Jointed leg	Walking.
	4th walking	Jointed leg	Walking.
Abdomen	1st swimmeret	Biramous paddles	Copulatory organs in male.
	2d swimmeret	Biramous paddles	Hold eggs in female.
	3d swimmeret	Biramous paddles	Hold eggs in female.
	4th swimmeret	Biramous paddles	Hold eggs in female.
	5th swimmeret	Biramous paddles	Hold eggs in female.
	Uropod	Heavy flat paddle composed of two oval plates	Swimming.

Respiration in the crayfish is carried on by means of gills attached to the basal *joints* of the appendages on segments, six to twelve inclusive. These gills are covered and protected by the lateral extensions of the cephalothorax. A current of water is kept flowing over the gills by the movements of the second maxillæ.

Internal Organs.—The digestive system consists of a short esophagus, leading to a two-chambered stomach. The anterior chamber, cardiac, contains an elaborate grinding apparatus, called the gastric mill, which thoroughly pulverizes the food. After the food is ground it passes to the posterior chamber, pyloric, where digestion takes place. The intestine is short, not coiled, and leads to the anus.

Excretion takes place through the pair of green glands located in the head and opening through a duct which leads to the exterior through the excretory pore at the base of the antenna.

The heart lies above the digestive system. Its contractions forces blood to all parts of the body, partially through closed blood vessels and partially through open sinuses.

The nervous system is well developed, with a dorsal brain with circum-esophageal ring connecting the brain to the ventral chain of ganglia. The senses of sight, equilibration, touch and the chemical senses, perhaps analogous to our senses of taste and smell, are well developed. The eyes are compound, composed of a large number of separate facets, perhaps 2000 or more. The facets are the six-sided ends of the prismatic units of the eye, called ommatidia. The mosaic theory of vision is generally accepted. Each ommatidium is supposed to contribute its part to the image, much as figures are made in the ordinary tile floor by placing various-colored tiles together. Such eyes are better adapted to seeing moving objects than they are to seeing form. Perhaps the vision of the crayfish and other arthropoda with compound eyes is much as ours is when we look through wire glass, *i. e.*, the glass laid down on poultry netting. The wires divide the area into a number of six-sided figures corresponding to the ommatidia. Vision is blurred by the translucent nature of the glass, but the slightest movements can be detected as the shadow of the object moves from one mesh, or one group of meshes, to another. The sense of touch is well developed in the antennæ and in the legs. The chemical senses are in the antennæ and in the mouth parts. The organs of equilibration are called the statocysts. They are a pair of hollow chambers lined with sensory hairs, located on the bases of the antennules. Each chamber contains a free-moving statolith. The statolith normally rests on certain sensory hairs when the animal is resting in a given position. In this way the position of the body is determined. It has been found that a small piece of iron could be substituted for the usual statolith and that by using a magnet the iron statolith could be held in a position that would not correspond to the position of the body under these conditions. The animal responds, not in accordance with the true position of its body, but with reference to the position of the statolith.

The sexes are separate. Copulation takes place in the late summer or early fall in some species and in the spring in others. The sperms are retained in the seminal receptacle until the eggs are extruded; then the sperms are forced out of the seminal receptacle. After fertilization the eggs are fastened to the swimmerets and retained by the female for about a month or until they hatch. The young leave the mother in about two weeks. Growth is usually completed by the end of the second year, although the animal may be sexually mature by the end of the first year.

Some Interesting Crustacea.—The Class Crustacea may be divided into three sub-classes: the Entomostraca, Cirripedia and the Malacostraca. The former are mostly small, marine and fresh water species that are usually called water fleas, since many of them swim with a peculiar leaping motion. Some are called fairy shrimps because they resemble the shrimps in general form, but are small and delicately colored or semi-transparent. The number of segments in the body is quite variable and there are no appendages on the abdomen. The Cirripedia are attached or parasitic forms enclosed in a shell. The bodies are greatly modified and the true relations were for a long time in dispute. The attached forms are usually called barnacles. The Malacostraca are usually larger than the Entomostraca, and the common forms are known as shrimps, lobsters, crayfish, or crawfish, crabs and sow bugs. Many species are marine, some species occur in fresh water and a few are terrestrial, living near the water or in moist situations.

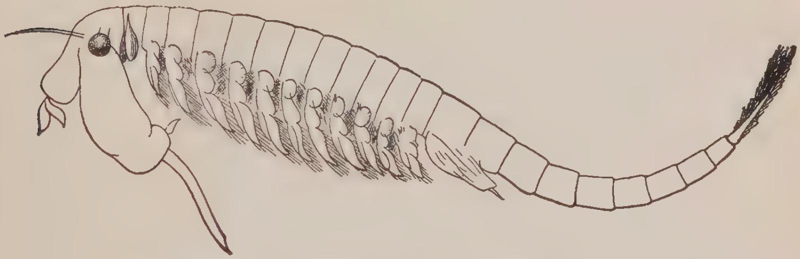


FIG. 92.—Fairy shrimp. *Branchipus vernalis.* (From Hertwig's Manual of Zoölogy, courtesy of Henry Holt & Co.)

The ENTOMOSTRACA.—The Entomostraca are usually divided into four orders: the Phyllopoda, the Cladocera, the Ostracoda and the Copepoda.

The *Order Phyllopoda* comprises the fairy shrimps (Fig. 92) and their kin. They are elongate shrimp-like animals with numerous pairs of flattened swimming legs which are also organs of respiration.

Most of the species are small, from ½ to 1 inch in length. Most of them live in fresh water, the one exception is the brine shrimp, which lives in salt lakes and pools. Many kinds are completely or nearly completely parthenogenetic, that is, their eggs develop without fertilization, and the males are rare or unknown. Many of the forms live in pools that dry up during the summer, and they show a remarkable adaptation to this habitat in that the summer is passed in the egg which can withstand complete drying up of the pools. When the spring rains come on again, and the pools fill up, the eggs hatch. The number of fairy shrimps that sometimes occur in a pool are almost beyond belief. The pink fairy shrimp, *Branchipus vernalis*, is often abundant in pools in the eastern United States. It is about 1 inch long. The members of the family Limnadiidæ are peculiar phyllopods with bivalve shells, resembling the shells of the river mussel and the clams.

The *Order Cladocera* (Fig. 93) includes the water fleas, the body of which is enclosed in a bivalve shell. The second pair of antennæ is very large and used for swimming. The number of swimming feet is usually four or more. The species of the genus *Daphnia* are enclosed in a beautifully marked shell terminating in a caudal spine which is often as long as the body. The species are small, measuring about $\frac{1}{10}$ inch in length.

The *Order Ostracoda* contains small bivalve crustaceans which live in salt or fresh water. Both pairs of antennæ are usually well developed and there are two pairs of swimming feet. The shells of some forms are beautifully marked with reticulating ridges or with spines or blunt processes. Thus many of the ostracods are among the most beautiful animals found in the plankton.

The *Order Copepoda* includes entomostracea with elongate bodies, biramous swimming legs and no shells. The head and thorax are fused into a cephalothorax. Copepods are both free-living and parasitic in their habits and the greater proportion of the species are marine. They are often very abundant as to number of individuals and furnish an important part of the food of fishes and other aquatic animals. The first pair of antennæ is usually large and is the important organ of locomotion, being used like the oars of a boat. The cephalothorax is usually large, the abdomen narrow and elongate with a pair of short processes at the posterior end bearing elongate setæ. The genus *Cyclops* contains common fresh water animals. The species of this genus are small, about $\frac{1}{10}$ inch long, with the antennæ shorter than the cephalothorax. And the females are frequently seen with a pair of egg sacks attached to the base of the abdomen. The eyes are united so that they appear as a single median eye, hence the name Cyclops, from the fabled race of men with but a single eye, has been used for this genus. The genus *Diaptomus* also contains a large number of fresh water species.

The antennæ are nearly as long as the body, otherwise they resemble Cyclops in general form. The parasitic Copeopoda are known commonly as fish lice, and they are commonly parasites of fishes.

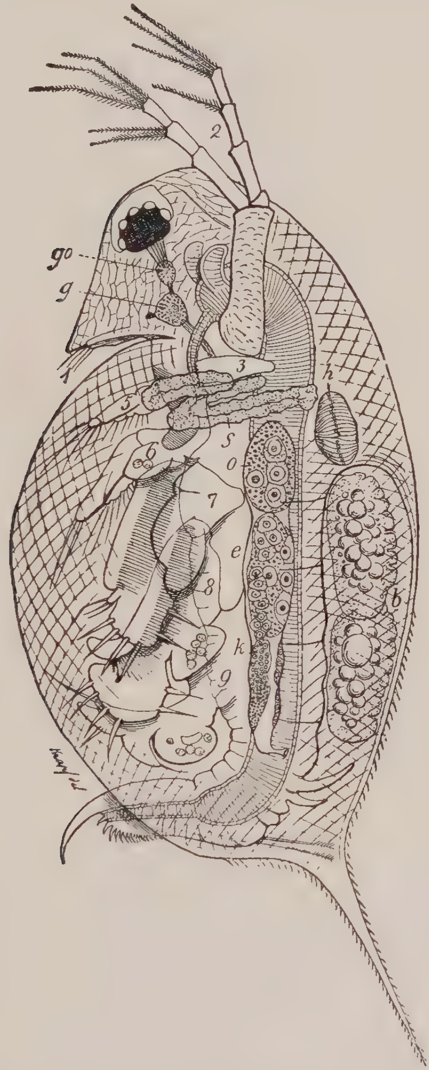


FIG. 93.—*Daphnia pulex.* *b*, brood chambers with embryos; *g*, brain with nauplius eye; *go*, optic ganglion; *h*, heart; *o*, ovary; *s*, shell gland. The eggs arise at *k*, and separate, forming in groups of four, as at *e*, of which one becomes the egg, while the others abort (*o*) and form food. The egg then passes to the brood chamber. 1, 2, first and second antennæ; 3, mandible (maxilla rudimentary and invisible); 5 to 9, legs. Alimentary canal cross-lined. (From Hertwig's Manual of Zoölogy; courtesy of Henry Holt & Co.)

THE CIRRIPEDIA.—The sub-class Cirripedia includes some of the most peculiar Crustacea. In fact, the group as a whole is so peculiar that their true relations were only definitely established about a hundred years ago. Most species are sedentary marine animals. A few are parasites on crabs. Of the non-parasitic forms there are two genera that are common. The genus *Lepas* (Fig. 94) includes the goose barnacles. These animals have a slender stalk and a shell of five plates enclosing the animal. They are common on floating objects and often foul the bottoms of ships. The rock

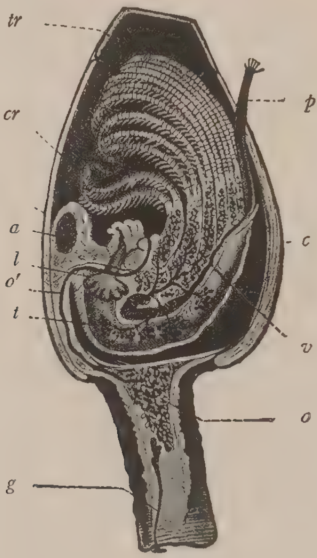


FIG. 94.—Anatomy of *Lepas*. *a*, adductor muscle; *c*, carina; *cr*, cirri (feet); *g*, cement gland; *l*, liver; *o*, *o'*, ovary and oviduct; *p*, penis; *t*, testis; *tr*, tergum; *v*. vas deferens. (From Hertwig's Manual of Zoölogy, courtesy of Henry Holt & Co.)

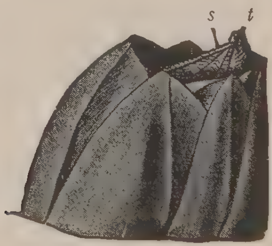


FIG. 95.—Acorn barnacle. *Balanus hameri*. Formed of rostrum, lateralia and carina, the operculum of scuta (*s*) and terga (*t*). (From Hertwig's Manual of Zoölogy courtesy of Henry Holt & Co.)

barnacles belong to the genus *Balanus* (Fig. 95). They are sessile or without stalks. The body is enclosed in a thick shell composed of a number of pieces which close over the animal, forming a conical or tent-like covering. The species of this genus are abundant on rocks in the between tide zone and on the bottoms of ships, often completely encrusting them.

THE MALACOSTRACA.—This sub-class contains a large number of of medium to large-sized Crustacea. The small- and medium-sized species do not have the segments of the thorax fused. These fall naturally into two orders, the Amphipoda and the Isopoda.

The Amphipoda are usually called beach fleas, as many of the species have their bodies compressed and live on the beach and hop about actively like fleas.

The Isopoda (Fig. 96) have the body depressed. The common sow or pill bugs which are frequently found under logs, stones and leaves in damp woods and in gardens and cellars are familiar to nearly every one. In addition, there are a number of forms that are parasitic on fishes. The gribble, *Limnoria lignorum*, is destructive to submerged timber by tunneling the surface, thus causing it to decay. The pond isopod is often troublesome in shallow wells, where it breeds in enormous numbers, making the water unfit for use. The cave isopod which is quite similar in general appearance, but is blind, lives in caves and deep wells.

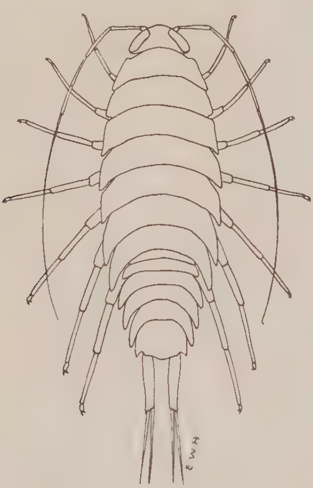


FIG. 96.—Sowbug.

The larger Malacostraca have the head and thorax fused into a definite cephalothorax covered with a carapace. The largest order is the *Decapoda*, which includes the shrimp, prawns, crayfish, lobsters, hermit crab and crabs. The name is derived from two Greek words, which mean having ten walking legs. The Sub-order Macrura includes the more aquatic members of the order. The body is elongate, cylindric and the abdomen is not fused with the cephalothorax. The second antennæ are long and the sixth pair of swimmerets, with the last abdominal segment or telson, form a tail fin.

The shrimps and prawns are small delicate forms found in marine, brackish and fresh water. The thoracic legs are weak and the first pair is not usually provided with a powerful pincer or claw. These animals are swimming animals, in contrast to the lobsters and crayfish which are creeping animals. The edible shrimp, *Crangon vulgaris* (Fig. 97), is found in shallow water on both the Atlantic and Pacific Coasts. If stranded by the tide it buries itself in the sand and remains until the tide comes in again. For this reason it is often called the sand shrimp. The prawns belong to the genus *Palæmonetes*, which live in brackish water, often ascending to where the water is fresh. The prawns resemble the shrimps in general appearance, but have two legs with claws or chelæ.

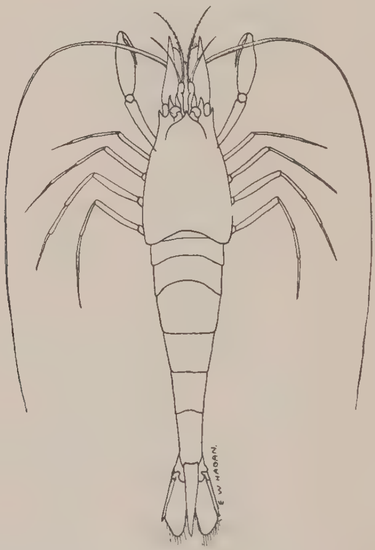


Fig. 97.—Edible shrimp. *Crangon vulgaris.*

The fresh water shrimp belongs to the genus *Palæmon.* It resembles the edible shrimp in general appearance, but lives in fresh water and is abundant in the Mississippi River system.

The lobster, *Homarus americanus* (Fig. 98), is a familiar marine animal resembling the common crayfish in general shape but is much larger and more powerful. It lives on the bottom of the ocean and hides in holes and crevices in the rocks. In summer it comes into the shallow water but in the winter it retreats to the deeper water. This animal is a scavenger, feeding on dead animal matter.

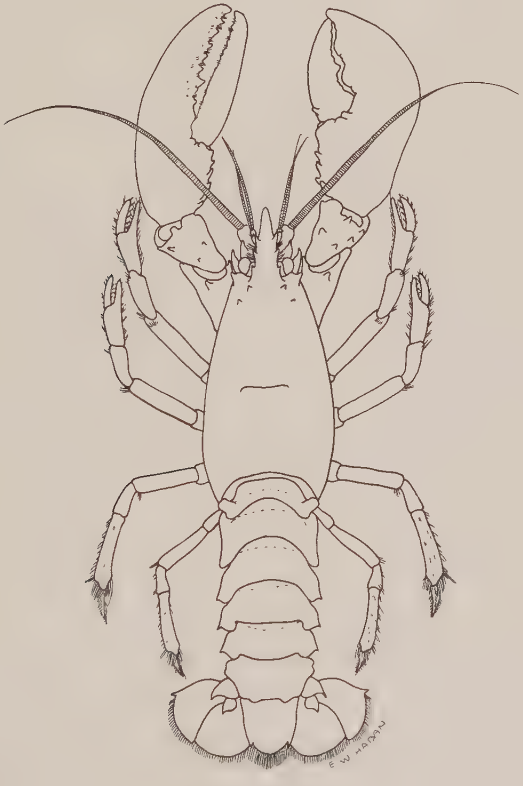


Fig. 98.—Lobster. *Homarus americanus.*

The crayfish or crawfish are fresh water forms, usually abundant in ponds, lakes and streams. Some forms are quite terrestrial, living in burrows in swamp lands and digging until they reach ground water. The mud from the burrows is brought out in little pellets which are stacked about the mouth of the burrow to make chimneys. Some chimneys are left open but some are neatly closed over. The crayfish of eastern North America belong to the genus *Cambarus* (Fig. 99), which has a number of species. The genus

Astacus (Potamobius) is found on the Pacific Slope and in Europe, but not in eastern North America.

The hermit crabs, *Pagurus spp.*, are peculiar crustaceans with a hard cephalothorax and soft abdomen. They appropriate shells of mollusks in which they live, dragging the shells about with them wherever they go, and retreating into the shells in time of danger. In some forms the claws are modified to fit the opening of the shell, thus forming a better defense against their enemies. The last pair of swimmerets is modified into recurved hooks for holding the animal in the shells.

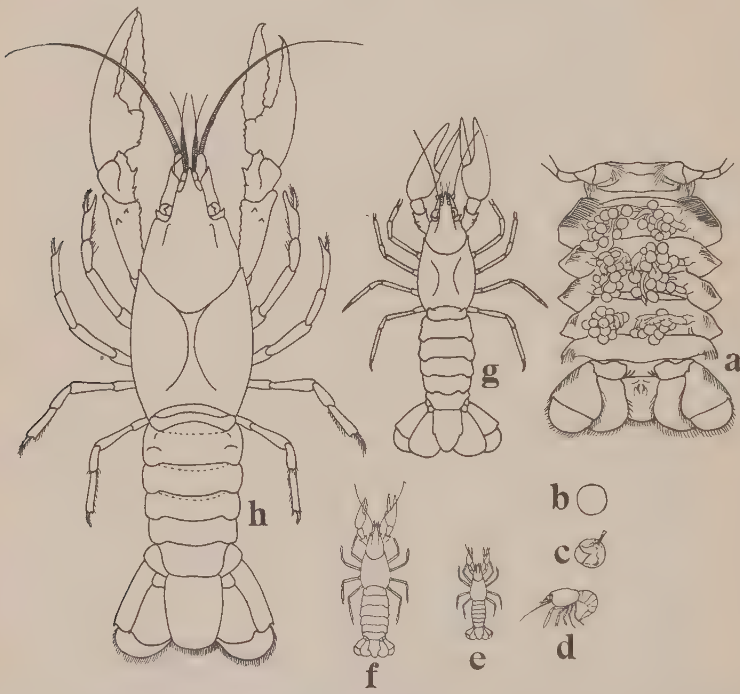


FIG. 99.—Life history of a crayfish. *Cambarus sp. a*, eggs attached to swimmerets; *b*, egg; *c*, first larval stage hatching through break in egg shell; *d*, second larval state; *e*, crayfish about three months old; *f*, crayfish about six months old; *g*, crayfish one year old; *h*, adult.

The crabs belong to the sub-order Brachyura. There are many interesting and curious forms, and since many species are abundant and conspicuous, they are familiar to practically everyone that has visited the sea coast. Most of the forms live in the shallow water along the coast. Some kinds, however, live at great depths, while others live abundantly in the between tide zones and some live on the land, often some distance from the water. Some kinds are active swimmers, some are creepers, some are active climbers about wharves especially and some forms are active runners. Some forms conceal themselves in cracks and crevices in the rocks and wait for their prey or hide from their enemies. Other forms hide themselves by burying partially in the sand, while still other forms build burrows in the sand or mud into which they retreat.

In structure the crabs differ remarkably from the other Crustaceans. The cephalothorax is broad and flat. The abdomen is reduced and folded under the cephalothorax. The antennæ are short and usually inconspicuous. The eyes are prominent, usually on long stalks, and may be folded back against the head in grooves shaped for their protection. The legs are well developed. The first pair is strongly chelate and is a powerful weapon of offense. If a claw is lost in combat it is regenerated at the next molt. The other legs are not chelate. In the swimming crabs the fifth pair is broad and flat and used like paddles.

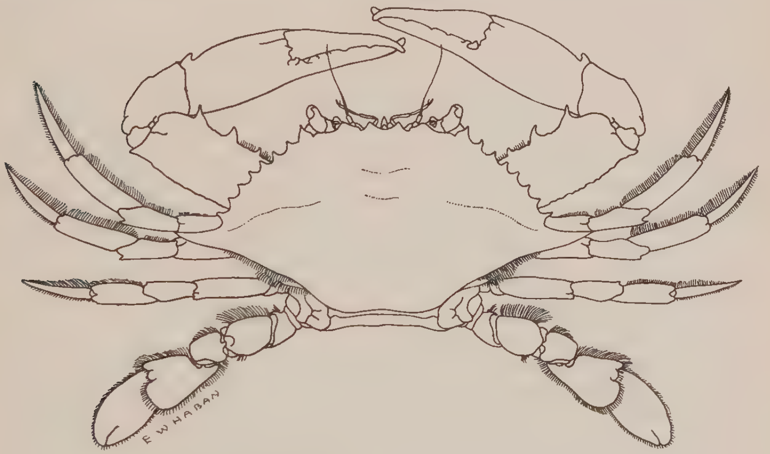


Fig. 100.—Blue crab. *Callinectes sapidus.*

There are 3 species of swimming crabs along the Atlantic Coast that are common. The best known of these is the blue crab, *Callinectes sapidus* (Fig. 100), sometimes called the edible crab because it is used for food quite extensively. When it is captured at molting time it is known as the soft-shelled crab; at other times it is called the hard-shelled crab. It is abundant in bays, sounds and rivers, often ascending to water that is quite fresh. It may be distinguished by the broad cephalothorax with a spine on each side.

The sand crab, *Ovalipes ocellatus*, is common on sandy beaches just at low-water mark, where it conceals itself by burying in the sand and waits for its prey. This also protects it from the pounding of the breakers. The carapace of this species is nearly round, otherwise it looks very much like the blue crab.

The green crab, *Carcinides mœnas*, is a more northern species, living in the between tide zones and hiding beneath rocks or other protection. It may be distinguished from the other swimming crabs by the fact that the cephalothorax is nearly as long as broad and by the fact that the claws are broad and short.

The rock crabs, *Cancer spp.*, are broad, powerful animals with short, broad claws. They live in the between tide zone or in shallow water in holes in rocks.

The spider crabs are peculiar crabs with very long legs. In some of the Japanese forms the legs may reach a length of several feet. One of the most peculiar eastern species is the *Lambrus pourtalesii*, called the long-armed crab. It has a rough, spiny cephalothorax with powerful front legs armed with short claws and covered with broad short spines.

The oyster crab and the mussel crab, *Pinnotheres spp.*, are peculiar, soft-bodied, degenerate crabs that live in the shells of the oyster or the sea mussel. This relation is perhaps mutually beneficial as the crabs receive protection and they are perhaps beneficial to the mollusks. Both species are small, weak, soft-bodied crabs. The oyster crab is familiar to every one who has eaten oysters as small pinkish or reddish animals, occurring with the oyster.

The ghost crab, *Ocypode albicans*, and the fiddler crabs, *Uca spp.*, are the outstanding terrestrial crabs along the Eastern Coast. While both crabs live most abundantly in the between tide zone near water, they occasionally wander far from the water. The ghost crab is of medium size and may be recognized by its nearly rectangular cephalothorax and whitish sand color. It lives in the hard, sandy beaches along the strand and makes its burrows in the upper part of the strand, usually well above high tide, sometimes well up in the dunes away from the water. These burrows sometimes reach a depth of 2 feet or more and usually have two entrances. The ghost crab retreats to his burrow in time of danger. If he is cut off from his own burrow he will enter the burrow of a neighbor. If this burrow is occupied he will retreat to another. This crab is very swift. It also has the habit of running rapidly over the sand, literally on tip toe, and then suddenly stopping and flattening itself out on the sand. As its color is almost exactly the color of the sand, this is a very good defensive ruse.

The fiddler crabs are peculiar crabs, in that one claw of the male, usually the right, is enormously enlarged, the fiddle, while the other is much smaller, the bow. These crabs are often very abundant in salt marshes along rivers and sounds. They dig shallow tunnels about 1 foot deep in the soft mud of the salt marsh. It is nothing unusual for vast stretches of salt marsh to be so completely tunneled that one would have difficulty in putting down the outstretched hand without touching one or more tunnels. The large claw is used by the male in a peculiar nuptial dance. One of the most peculiar sights to be seen in the salt marsh is a whole area of these strange little fellows, all in unison, raising and lowering this relatively enormous claw.

Economic Importance.—Economically speaking, the Crustacea constitute a very important class of animals. They are extensively used for food. For this purpose the lobster, the various species of crabs, the shrimp, the prawns and the crayfish are all important, and will be discussed in detail later. A few forms are destructive to crops. Many of the forms furnish a large percentage of the food of fishes that are used for food. This applies not only to the larger forms, but many fishes that are important as food for man subsists quite largely on the minute entomostraca. The barnacles are important because they foul the bottoms of ships.

The Lobster and Lobster Fishing.—The lobster, *Homarus spp.*, is the most important of the Crustacea used for food. While it occurs as far south as North Carolina, the commercial fisheries are in the New England States, Massachusetts and Maine furnishing the bulk of the catch. A few years ago the lobster was threatened with extinction because it had been overfished, but a careful study of the life history showed that the critical period in the life of the lobster, *i. e.*, the period when most of them were killed, was during the time when they were swimming about at the surface of the sea. Later, when they settle to the bottom they are better able to care for themselves. A method was devised to carry the larval lobsters through this critical period.

The female lobster carries the eggs on the underside of the abdomen until they hatch. The larval lobsters swim about at the surface of the ocean for two weeks or longer. They then molt and change their form and become creeping animals on the floor of the ocean. The eggs are stripped from the female and placed in jars until they hatch. Or the females with eggs may be placed in the breeding crates until the larvæ hatch. The larval lobsters are then placed in crates in the ocean and a circulating current is maintained. The larvæ are fed on raw beef or other food until they reach the bottom stage, and then they are released. In this way, millions of lobsters are raised and released each year. This method, together with better regulations in regard to the size of the lobsters that may be sold and regulations covering the size of lobster pots or traps, have saved the lobster industry.

Lobsters are trapped in the so-called lobster pots. These are usually crates made out of slats with the ends closed by conical entrances made of wire netting. The slats are placed far enough apart so that the small lobsters unfit for market may escape. These pots are baited with fish and dropped to the bottom. A line with a float being attached to each pot, so that it may be readily located. The pots are placed in shallow water in the summer and in deeper water in the winter and visited once or twice a day if weather permits. The trapped lobsters are removed and sent to market alive.

The lobster is justly prized by epicureans as the finest of sea foods. A steadily increasing demand with a decreasing supply has caused the price to increase rapidly. The only way the fisheries can be maintained is to enforce the regulations in regard to minimum size and to increase the number of young lobsters released each year.

Crayfish as Food.—In Europe and on the Pacific Coast, where the large crayfish of the genus *Astacus* occur, they are seined and used extensively for food. In the East, where the smaller species of Cambarus occur, they are not so extensively used. In some states, Wisconsin, Minnesota, Arkansas and Louisiana, crayfish are captured quite extensively and used for food. The abdominal muscles do not differ essentially from the abdominal muscles of the shrimps and prawns, and there is no reason, save prejudice, why crayfish should not be used in this way.

The Crab as Food.—The blue crab is the crab most extensively used for food in eastern North America, although practically all crabs are edible. This preference is due in large measure to prejudice, and to a certain extent, at least, to the ease with which the blue crab may be taken in large numbers. Blue crabs are used in two ways, as hard-shelled crabs and as soft-shelled crabs. Since the method of capture, the method of cooking and the method of serving is entirely different in each case, they may be treated as two distinct species. The hard crab occurs in shallow water, in rivers, sounds and bays. It is captured either in pots or traps similar to lobster pots, or on lines baited with fish or other meat. The crab will be attached to this bait, and if the line is raised carefully the crab will hold on to the bait until it is near the surface. The crab may then be taken in a dip net. Hard-shelled crabs are boiled, the shell is cracked and the meat removed and cooked in a variety of ways.

The soft-shelled crabs hide in the grass along shore and are usually captured by the use of dip nets. The demand for soft-shelled crabs has led to the practice of holding hard-shelled crabs in pens until they have molted and then sending them to market. Soft-shelled crabs are sent to market alive in crates, packed in seaweed. They are cooked by frying in deep fat and are eaten shell and all.

Shrimps as Food.—Both the salt water and fresh water shrimps are extensively used for food. They are captured in seines. The abdomen is severed from the cephalothorax and only the powerful abdominal muscles are used for food. Part of the catch is sent to the market packed in ice and a part is canned. They are also used extensively as bait for catching other sea food.

Crustaceans as Pests.—Some species of crayfish are pests in river bottoms, especially along the Mississippi River. They are often found at the rate of 10,000 per acre. These animals come out at night and devour the young cotton plants and other crops. No really satisfactory method for their control has been devised. They sometimes cause serious trouble by boring into levees, thus weakening them.

Sow bugs are troublesome pests in greenhouses, mushroom houses and sometimes in fields. The greenhouses and mushroom houses, being warm and damp, make ideal breeding places for these animals. In the field they are usually only troublesome to crops, like strawberries, that are heavily mulched. The mulch makes an ideal place for the sow bugs to breed and they often increase to such an extent that they devour the entire crop.

CHAPTER VII.

THE SPIDERS, SCORPIONS, TICKS, MITES, MILLIPEDS AND CENTIPEDS (CLASSES ARACHNIDA AND MYRIAPODA).

- Class Arachnida
  - General anatomy and physiology
  - Web building
  - Some common spiders
  - The ticks and diseases
  - The mites
    - Itch mites
    - Scab mites
    - Chiggers
    - Chicken mites
    - Red spiders
  - The scorpions
- Class Myriapoda
  - The millipeds
  - The centipeds
- Poisonous Arachnida and Myriapoda

CLASS ARACHNIDA.

This class includes the spiders (Fig. 101), ticks, mites, scorpions and related forms. In this group the head and thorax are fused into a cephalothorax, the abdomen is segmented or not, and sometimes it is fused with the cephalothorax into a body without evident external divisions. There are no antennæ. The mouth parts consist of a pair of cheliceræ, a pair of palpi and an unpaired labium. A chelicera consists of a basal segment and a terminal claw. The

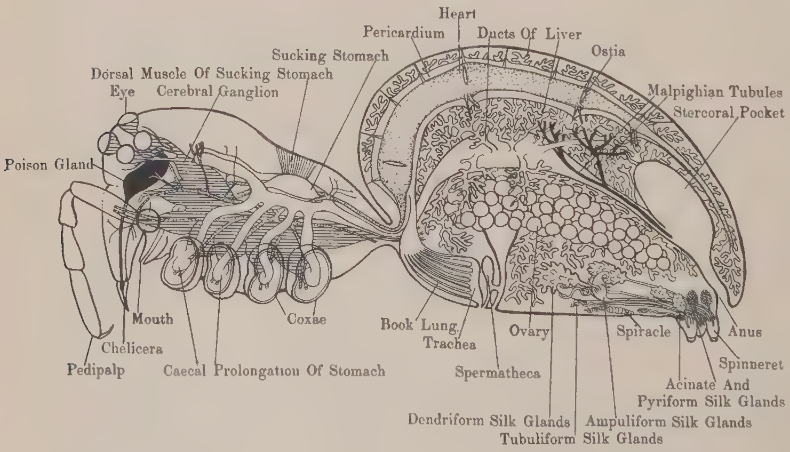

Heart
Pericardium
Ducts Of Liver
Ostia
Sucking Stomach
Dorsal Muscle Of Sucking Stomach
Eye
Cerebral Ganglion
Malpighian Tubules
Stercoral Pocket
Poison Gland
Mouth
Coxae
Book Lung
Ovary
Spiracle
Anus
Chelicera
Trachea
Pedipalp
Caecal Prolongation Of Stomach
Spermatheca
Spinneret
Acinate And Pyriform Silk Glands
Dendriform Silk Glands
Ampuliform Silk Glands
Tubuliform Silk Glands

Fig. 101.—Diagram of the spider. (Redrawn from Comstock.)

basal segments hold the prey and masticate it. The duct from the poison gland opens near the tip of the poison claw. The claws are used to seize while the poison paralyzes the victim. The palpi are jointed leg-like structures. They may be used for seizing the prey as in the scorpions, as sensory organs in the spiders and as copulatory organs in male spiders. There are always four pairs of legs in the adult. They are the organs of locomotion, but in certain forms the second pair of legs are evidently quite sensitive to touch and are used as feelers. The abdomen is distinctly segmented in the scorpion and its allies. In the spiders it is without evident segmentation and in the ticks and mites it is fused with the cephalothorax. In the spiders the abdomen bears the openings of the book lungs on the ventral side near the base. These are sac-like respiratory organs which are filled with hollow leaf-like folds. These leaves are held apart so that air may circulate freely. The blood flows in the hollow spaces of the leaves and is aërated. At the end of the abdomen are the spinnerets, from which the silk for making webs is spun (Fig. 101).

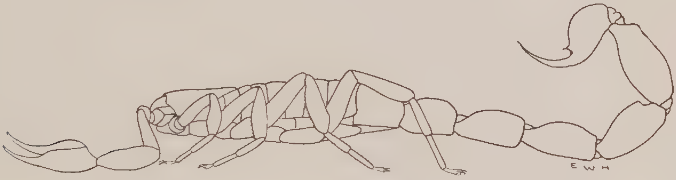


FIG. 102.—Scorpion.

Some Common Arachnida.—The class Arachnida is divided into a number of orders. Only the most important or those that contain forms that are unusually interesting will be discussed.

Order Scorpionida.—This order includes the true scorpions. These animals have the head and thorax fused into a cephalothorax with four pairs of legs. The pedipalps are long, with claws at the tip. The abdomen is segmented, with the anterior segments or body segments, broad, the cauda or tail segments narrow.

Scorpions (Fig. 102) are chiefly nocturnal in their habits and feed principally on insects. While they have a poison sting in the end of the tail and can inflict a severe sting, it is seldom fatal. These animals are mostly tropical in their distribution. A few species occur in the United States, chiefly in the Southwest. *Centrurus carolinianus* is a yellowish-brown species more or less marked with black and is about 3 inches long. It occurs in the South Atlantic States. *Vejovis carolinus* is a smaller, reddish-brown species, about 1½ inches long, and occurs from the South Atlantic States westward to California.

Order Pedipalpi.—This order includes the whip scorpions (Fig. 103), *Mastigoproctus spp.* The pedipalpi are short and stout. The forelegs are long and slender. The cephalothorax is elongate, nearly as long as the abdomen. The abdomen is segmented and terminates, in our commonest species, in a long, whip-like appendage. This species is about 5 inches in length, dark brown in color and occurs under logs in sandy places, in the Gulf States and west to Arizona. Although this animal is generally feared, and is said by some to have a poisonous bite and by others to be able to sting with the end of its tail, no poison glands have been found.

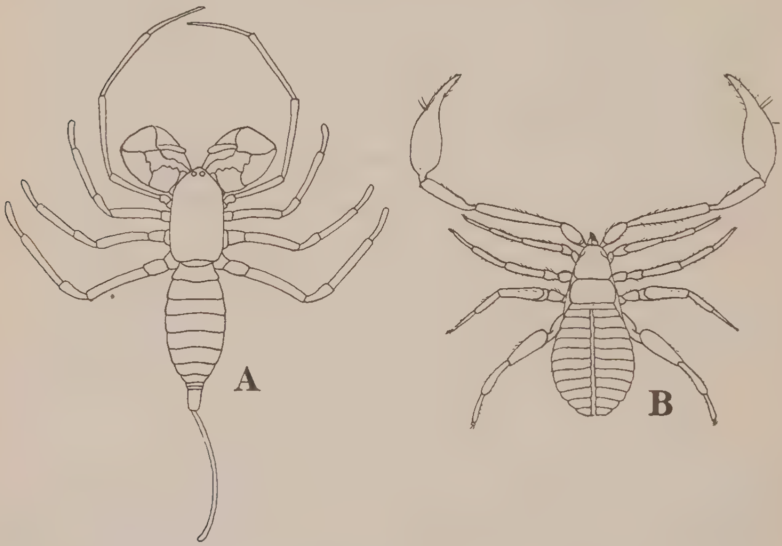


Fig. 103.—A. Whip scorpion (redrawn from Comstock). B. Pseudoscorpion.

Order Pseudoscorpionida.—These are small, flat animals with greatly developed pedipalps which are used as sensory organs or feelers. The pseudoscorpions live under the bark of trees, under leaves, or stones, in cracks in buildings and are sometimes abundant in chicken houses. It is believed that they feed commonly on mites and small insects.

Order Phalangida.—The daddy-long-legs, grandaddies or harvestmen, are familiar to all country children (Fig. 104). Their bodies are short and compact, the cephalothorax small and the abdomen externally segmented. The legs are very long and slender, pedipalps long, eyes on a prominent tubercle in the middle of the cephalothorax. The eggs are laid in the fall and hatch the following spring. It is believed that some of our species do not survive the winter, while others hibernate under trash. These are active animals, usually abundant in harvest fields, hence the name harvestmen. Country boys have many fancies regarding these little creatures, believing, for instance, that if held by the hind leg, they will indicate with their long second legs the direction to go to find cows on pasture or to find other boys. Authorities do not agree as to the food of the harvestmen, some contending that they eat live insects and others that they feed only on dead insects or the juices of fruits or vegetables. Our commonest species belong to the genus *Liobunum*. The body is about $\frac{1}{3}$ inch long and the legs from 1 to 2 inches in length.

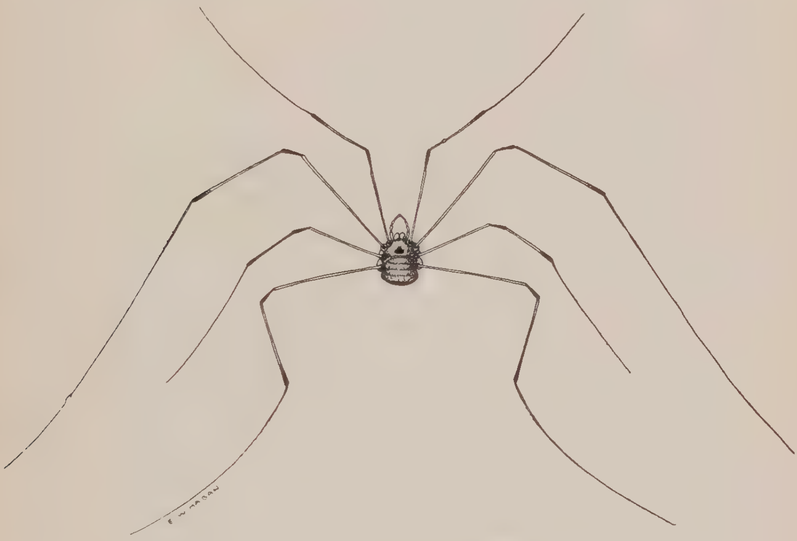


Fig. 104.—Daddy-long-legs.

Order Araneæ.—The spiders are almost too well known to need description. The cephalothorax is usually rectangular. The abdomen is joined by a slender pedicle. It is nearly spherical and unsegmented. The eyes are usually eight in number and arranged in two rows of four each. The mandibles consist of two segments, a heavy basal piece and a terminal poison claw. The pedipalps are leg-like. In the male they are modified into copulatory organs. The cephalothorax also bears the four pairs of legs. These are usually elongate. The abdomen bears the openings of the book lungs on the ventral side near the base. The book lungs are paired respiratory organs composed of a number of thin laminæ containing blood. The laminæ correspond to the leaves of a book and are held apart so that the air which enters through the slit in the body wall may circulate freely and aërate the blood.

Web Building.—Spiders spin threads for making webs and for other purposes by means of the spinnerets located at the posterior end of the body. There are usually six pairs of spinnerets. Each spinneret has a large number of small openings at the tip. These openings bear the spinning tubes, and it is through these tubes that the silk is forced to make the thread. A thread may be composed of a large number of very small strands or it may be composed of a few large strands. According to Comstock, the more common kinds of threads spun by spiders are the dragline, the attachment disk, the swathing band and the viscid thread. The dragline is used by the spider in dropping from a higher to a lower elevation. It is not viscid. It is fastened to the support by the attachment disk. The viscid thread is used to capture prey in webs. As its name implies, it is sticky and will adhere to any object that touches it. Insects flying against viscid threads become entangled and are often completely wrapped up in the swathing bands.

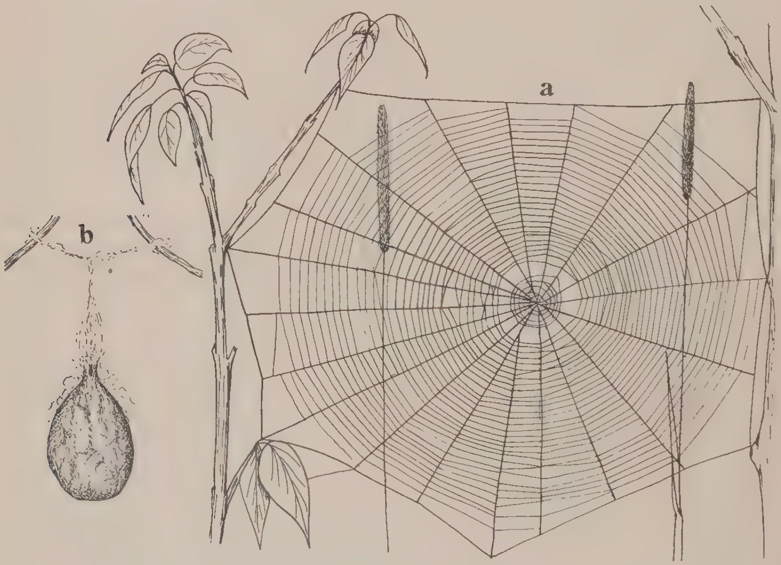


Fig. 105.—*a*, web of orb weaver; *b*, winter egg case.

Some spiders spin the threads of silk together to make webs for the capture of prey, but other spiders do not make webs. The most familiar webs are the orb webs (Fig. 105) of the garden spiders, the funnel webs of the grass spiders and the irregular webs of the house spiders. The typical orb webs consist of a number of non-sticky threads radiating from a center with a more or less regular spiral of viscid silk. The method of making the orb webs is very interesting and is worthy of careful study. In building an orb web, the first part to be built is the bridge. The bridge is built between two branches of a tree or shrub, between two posts or between a post and a vine or any other similar opening. Sometimes the spider fastens the dragline for making the bridge to one support and then walks to the other support spinning the dragline as it goes. Sometimes the bridge is fastened to a higher support and the spider drops spinning a thread as it goes and thus reaches the second support. Sometimes the spider spins a thread for the bridge and allows it to be caught up by the wind and carried to the second support. In any case, the line is drawn tight and the bridge is used to carry the spider back and forth for future operations. It is usually strengthened by additional lines. After the bridge is built the spider encloses the area that the web is to occupy by an irregular framework. This is done by fastening a dragline at a convenient point and then by walking or dropping to another point spinning dragline as it goes. The loose line is then drawn tight and fastened. After the framework is finished the radii are spun. The first radius is usually spun by dropping from the top of the framework to the bottom and then drawing the dragline tight. The second radius is fastened near the center of the first radius and the spider walks along the first radius and the framework, spinning a dragline and then draws this line tight and fastens it to the framework. The spider then returns to the center and repeats the operation until the whole area to be covered by the web is crossed by radiating lines like the spokes of a wheel, the framework forming an irregular rim. The center of the web is usually strengthened by a hub and then the spider spins an irregular foundation spiral of non-sticky thread, starting at the hub and extending nearly to the framework with the turns far apart. The foundation spiral is used by the spider as a platform for building the sticky spiral which is the functional part of the orb web. It is the only part of the web that is composed of viscid threads. In spinning the sticky spiral, the spider starts usually at the lower part of the web and takes a few irregular turns and then spins a quite regular spiral with the turns close together until it reaches nearly to the hub. The web is thus complete and the spider may rest in the center, waiting for its prey to become ensnared or it may have a retreat at one side under a leaf, where it waits until the prey becomes ensnared and then rushes out to devour it or wrap it in the swathing band.

The grass spiders spin a flat sheet of web and a funnel-shaped retreat which may lead to a den under a stone. The spider remains in the funnel until some luckless insects falls on the web, when it rushes out and devours it.

Many of the house spiders build webs of threads that cross each other in a very irregular manner, thus forming a very efficient trap for flies.

Some Common Spiders.—A number of spiders have taken up their abode with man and are common about houses, barns and other buildings. Certain of these spiders build irregular webs without retreats, while others build webs with retreats. The common house spider, *Theridion tepidariorum*, builds an irregular web in the corners of rooms, windows, doors and similar situations. When full grown it is about ¼ inch long, with a small cephalothorax and a large spherical abdomen. The long-legged house spider (Fig. 106), *Pholcus phalangiodes*, is another spider that builds an irregular web. It is about ¼ inch long with slender abdomen and very long, slender legs. It builds its web in cellars, in the basements of bank barns and other damp situations. It is more common in the South.

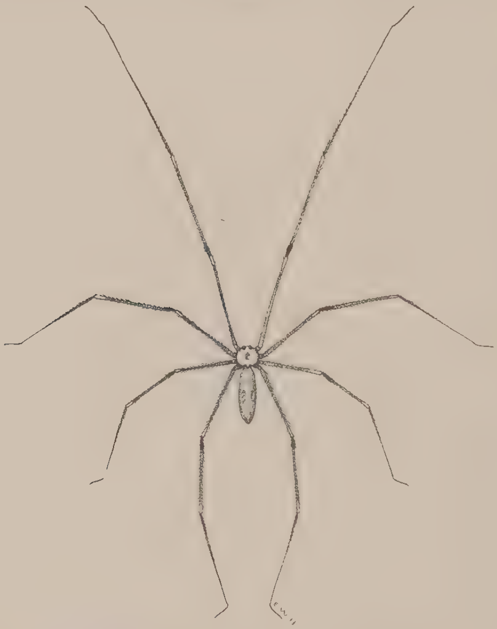


FIG. 106.—Long-legged house spider. *Pholcus phalangiodes.*

The barn spider, *Tegenaria derhami*, builds its sheet web with a funnel retreat like the grass spiders' webs in barns and other outbuildings more commonly than in houses. The web is usually placed in the corner of a window or in the corner between the studding and the walls. This spider is a heavy-bodied species, nearly ½ inch long, with short, heavy legs.

The species of *Dictyna* and *Fillistata* that live about houses build very irregular webs with retreats in convenient holes. The webs are composed, for the most part, of very coarse threads, which collect dust and make the webs very conspicuous.

The garden spider or orb web weavers, *Family Argiopidæ*, form a large family, with numerous species of variable form. Some species are long and slender, while other species are short and stout. Some species have elongate parallel-sided abdomens, others have smooth, spherical abdomens and still others have abdomens that are nearly triangular in outline, sometimes with grotesque spines. All agree, however, in building orb-shaped webs. The method of building these webs has already been described.

The grass spiders or their sheet-like webs with funnel-shaped retreats are familiar to every one that has been in the country in the fall, as these webs collect dew and are usually very abundant in pastures and very conspicuous in the early morning before the sun has dried up the dew.

Many of our spiders do not build webs. Perhaps the most familiar members of this group are the ground or wolf spiders. Many of the species of this group are large, robust, grayish-brown in color. The females have the common habit of carrying their egg cases about with them. These spiders are seen commonly running about on the ground and some species build tunnels in the ground. The entrances to these tunnels may be surrounded by a turret composed of bits of small twigs or of pine needles.

The jumping or tiger spiders, *Family Attidæ*, are mostly small, brilliantly colored species. Some species have bright-red abdomens while others show metallic greens, blues or coppery reflections. The more common species have a broad stout cephalothorax and a small abdomen, covered with short hair. These spiders are hunting spiders that wait for their prey, pouncing upon it like tigers. They seem to be able to jump forward, backward or to one side with equal ease. The prenuptial dance of the male has been carefully studied by the Peckhams and is described as an elaborate display of brightly colored appendages.

The typical crab spiders, *Family Thomisidæ*, are small. They have elongate first and second legs which give them a characteristic crab-like appearance. They lie in ambush for their prey. One of our common species is pale yellow, more or less marked with red and is found commonly in the flowers of golden rod, where it waits for some luckless fly.

The tarantulas, *Family Aviculariidæ*, are mostly large, powerful, hunting spiders. The trap-door spiders though rare are very interesting tarantulas, because they have the habit of building tunnels which are closed by a hinged lid or stopple-like cover which the spider can close in time of danger. The tarantulas and other supposedly dangerous spiders are discussed in another connection.

The Ticks and Diseases.—The ticks (Fig. 107) are the largest representatives of the order *Acarina*. Since they are all parasitic forms and are common on man and his domestic animals, they are fairly familiar to everyone. Their mouth parts have been modified for attachment to their hosts. These consist of a pair of jaws with hooks and a modified beak or rostellum, with numerous, recurved spines. The body is not distinctly separated into cephalothorax and abdomen and the fully engorged ticks look like beans or other seeds.

The life histories of a number of species have been studied and they all agree in essential details. They mate and after the females become fully engorged with blood they drop to the ground and lay an enormous number of eggs, usually several thousand. These eggs hatch in a few weeks in the summer or the eggs laid in the fall may remain over winter and hatch the following spring. The larval ticks are known commonly as seed ticks. They have only three pairs of legs and the body is flat and more or less triangular in outline. Soon after hatching the larval ticks climb up on the grass, weeds and shrubs and there wait for a suitable host to pass. They take hold of the host by means of their elongate front legs. It is said that larval ticks waiting on plants in this way will respond to the slightest suggestion of a passing host, such as the jarring of the plant by brushing against it, the jarring of the ground or even the passing of a shadow which happens to fall upon them. Any stimulus of this kind will cause the quiet, waiting ticks to rise up and commence to wave their front legs about in the hope that they may reach a suitable host. Having reached a host, they bury the head and commence to feed on the blood. After feeding for a time, they moult to the nymphal tick which has four pairs of legs. After another feeding period, they moult again and assume the adult

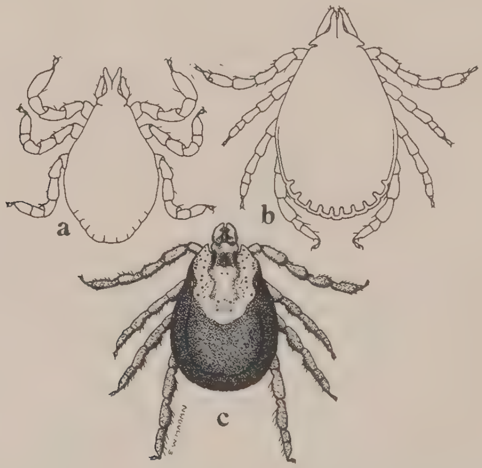


FIG. 107.—Spotted-fever tick. *Dermacentor venustus*. *a*, larva; *b*, nymph; *c*, adult.

condition. In moulting, the tick may remain on the same host or it may drop to the ground. If it drops to the ground it must then wait until it can attach itself to another host.

From their parasitic habits, it is not surprising that ticks spread diseases. Perhaps the most important disease transmitted in this way is the so-called Texas fever of cattle (Figs. 108 and 109). This disease has been one of the greatest handicaps to the development of the raising of cattle and the dairy industry in the southeastern United States. This disease which belongs to the Protozoa is discussed on page 350. By establishing a quarantine line and prohibiting the movement of cattle across this line, by dipping or spraying tick-infested cattle with an arsenical spray fatal to ticks and by proper rotation of pastures, Texas fever is being eliminated from the South.

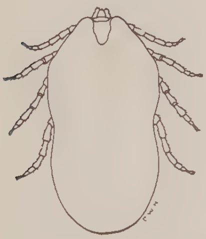


FIG. 108.—Cattle tick. *Margaropus annulatus.*

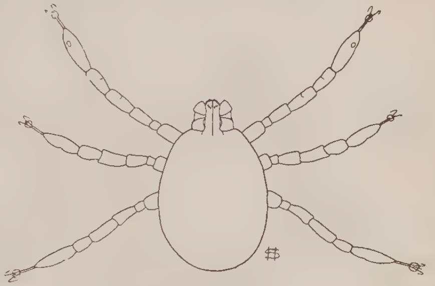


FIG. 109.—Larva cattle tick.

The only human disease of any importance in this country that is spread by ticks is the Rocky Mountain spotted fever, transmitted by the spotted-fever tick which feeds on a variety of hosts besides man including domestic animals and a number of wild rodents. Control has been directed toward prevention of infected ticks from biting humans, their control on domestic animals and the destruction of rodents in the spotted-fever territory. This is a highly fatal disease of man, but fortunately it is restricted to a very small area of the country in the Rocky Mountains, chiefly in Montana, Idaho and Wyoming.

In addition to these two ticks, there are a number of others common in the United States which are usually known as wood ticks or dog ticks. They are parasites of various mammals and are frequently troublesome to persons who live or camp in the woods. Their bites are very severe, sometimes producing paralysis. The sores are aggravated by the fact that most persons attempt to remove ticks by force. In doing so, the beak is left in the wound. The proper method is to place a drop of oil on each tick. This causes the tick to release the mouth parts and it may be easily removed.

The larvæ or seed ticks are often especially troublesome because they occur in such large numbers in the woods. When attacking humans they literally bury themselves in the skin, setting up an intolerable itching. They may be prevented by anointing the shoes and clothing with oil of sassafras or other repellents.

The Common Mites.—The term mites is used here in its common or vulgar sense to include only the small members of the Order Acarina, as the larger members have been discussed under the ticks. Mites are, therefore, small arachnids, sometimes without evident division between cephalothorax and abdomen. The mouth parts consist of the mandibles and the palpi. The mandibles are variously modified, depending upon the food eaten and the palpi are modified as organs of touch or organs of prehension for securing food or for clinging to their hosts. The legs are typically four pairs in the adult with three pairs in the larva. Some of the mites are plant pests of great importance; others are important pests of man or his domestic animals, while others are predators or parasites of injurious insects and are, therefore, of value to man, and some live as scavengers on decaying vegetable matter or other débris.

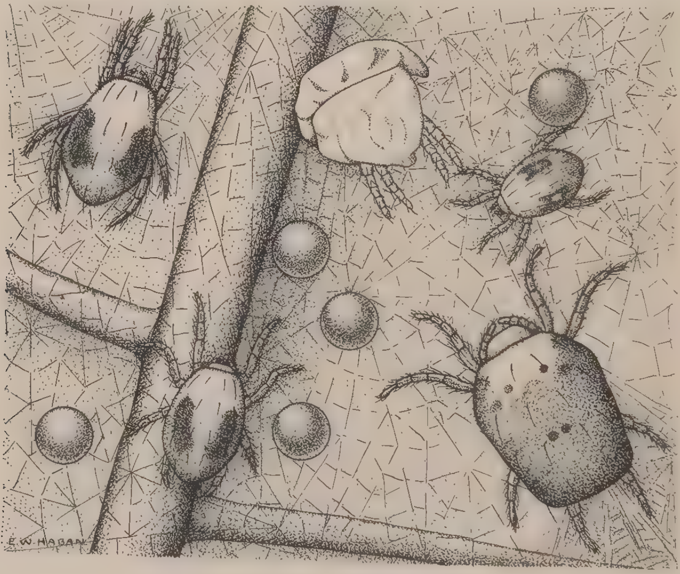


FIG. 110.—Red spider. *Tetranychus bimaculatus.*

There are a number of mites that are important pests of plants, but only two or three of the more important can be discussed here. The red spiders (Fig. 110) are mites that spin a slight thread, especially on the undersides of the leaves. They are important pests in greenhouses, where they are frequently destructive to a great variety of plants. In the South one species of red spider lives over the winter on violets and other plants and weeds that remain green. Then in the early summer they migrate to rank growing weeds and eventually to cotton. If the weather is favorable to the mites they frequently do great damage to the cotton. Their attacks cause the leaves to turn red and drop off. For this reason, the disease is frequently called rust. Red spiders may be controlled in greenhouses by fumigation. In the field control is more difficult, but may be effected by destruction of the violets and weeds that harbor red spiders during the winter and by dusting with sulphur and other compounds.

The clover mite is a pest that is sometimes very destructive to clover and fruit trees. It is also frequently troublesome because it enters houses in its fall migrations. Untold thousands frequently enter houses in this way. And since they are so small, it is practically impossible to keep them out. They do no harm save that their swarming over the house is a nuisance. This condition may be avoided by not growing clover near the house or by spraying the outer walls of the house below the windows with kerosene which will repel the mites.

The pear leaf blister mite is a serious enemy of pears and apples in parts of this country. This mite produces distinct blisters on the leaves which cause the leaves to drop. Control consists of an application of lime sulphur in the fall as soon as the leaves are shed.

Several species of mites are parasites of man. The only one that is an important, permanent parasite of man is the itch mite which produces the loathsome disease called itch. This disease was formerly one of the great scourges of mankind At present, however, a knowledge of the disease and its cause has practically wiped it out in communities where modern sanitation is observed. The itch mites are minute, nearly circular animals, about $\frac{1}{100}$ inch long, hence just barely visible to the naked eye. The females make tunnels beneath the epidermis of the skin, especially in the thin, moist skin between the toes and fingers and in the groins and armpits. Eggs are laid in these tunnels and hatch in about a week. The six-legged larvæ remain in the tunnels. In about two weeks the larvæ change to nymphs which have four pairs of legs. The nymphs become sexually mature in a week's time and wander out to the surface of the skin, where they mate. The males then die and the females dig new tunnels in which they lay their eggs. In this way, especially, when aided by scratching caused by the itching, the mites may be spread over the body or may be transferred from one person to another by direct contact or by contact with unclean towels, bed clothing, etc. The remedies for itch are perfectly obvious, scrupulous cleanliness and avoidance of contact with infected persons. If itch is accidentally contracted it may be cured very readily by taking a warm, soapy bath which loosens the pimples and scabs, followed by application of sulphur ointment which will kill the mites. The applications must be repeated in order to destroy the larvæ which hatch from eggs that have not been killed. The clothing and bed clothing must be sterilized by boiling.

Mites similar to the itch mites of men produce the common mange (Fig. 111) of dog and cats and occasionally of the horse and pig and the scab of sheep (Fig. 112). In severe cases of mange the hair is shed from small or large patches and the animals scratch themselves, producing infected sores. In a similar way, the sheep scab mite attacks the sheep causing it to rub itself. In severe infection patches of the wool are rubbed off. These patches of wool may be left adhering to fence posts, trees or buildings. The mites transfer themselves to uninfected animals that come in contact with this wool. The standard remedy for these mites is to dip the animal in a dip containing sulphur or nicotine or both. These substances or creosote or coal-tar derivatives are commonly used as the base for mange cures. Most of these remedies are effective only when application is repeated and accompanied by a thorough renovation of the sleeping quarters of the animals. The mange mites of domestic animals may infect man, but such infection is only temporary.

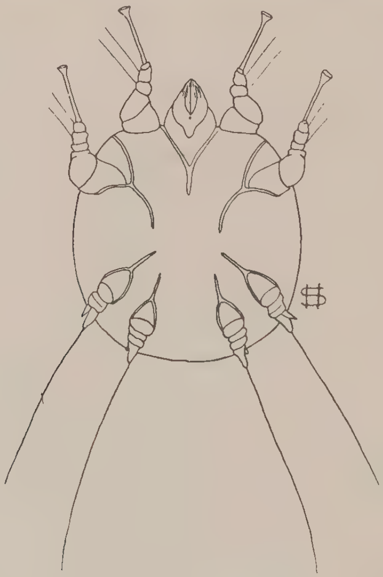


Fig. 111.—Mange mite.

Another group of mites that is very troublesome to man includes the larvæ of certain mites that are predators on insects or that are scavengers or that feed on food substance. All the mites of this group are temporary parasites on man and disappear in a short time if the source of infestation is removed.

The larvæ of the common *Pediculoides* produce a troublesome rash known as miller's or thrasher's itch. The adults of this mite prey upon the larvæ of grain moths, grain beetles, pea and bean weevils and other insects. Men thrashing grain and millers and others handling grains or seeds infested with these mites develop a serious rash. Sometimes new straw is used for bed ticks and infestation acquired in this way.

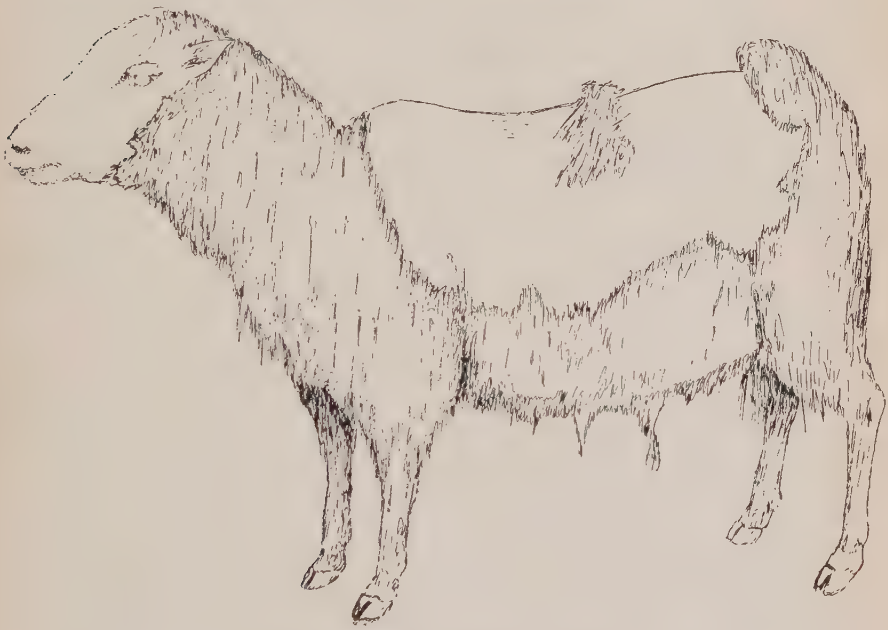


FIG. 112.—Sheep injured by scab mite.

The common red bug or chigger is another of these temporary parasites of man and many other vertebrates. According to Ewing, it is the larval stage of a mite that is not a parasite of insects but may be carried about by turtles, snakes and perhaps by other animals. It is very abundant in the summer in the South, especially in woods on fallen logs and in blackberry thickets. It attacks man by inserting the mouth parts at the base of a hair follicle and sets up an intolerable itching, which results in sores that may become infected. This is a serious disease for many people, but fortunately most people who live and work in infested regions gradually acquire immunity. The mites may be prevented from attacking man by anointing the clothes and shoes and the skin of the lower part of the legs with oil of sassafras, kerosene or sulphur. A bath in warm soap suds made from strong laundry soap will kill most of the mites if taken immediately after being in an infested region.

Grocer's itch is produced by the common cheese mite which feeds on a variety of food substances, including most of the common groceries, such as flour, meal, cereals, cheese and dried meats.

The chicken mite (Fig. 113) is a troublesome pest of chickens, especially in the South. During the day it hides away in cracks in the roost and about the hen house. At night it crawls out and attacks the roosting chickens, causing a troublesome itching. Poultry kept in badly infested houses lose weight and egg production is reduced. Only properly constructed hen houses that can be readily and thoroughly cleaned and sprayed with solutions containing sulphur, carbolic acid or creosote should be used.

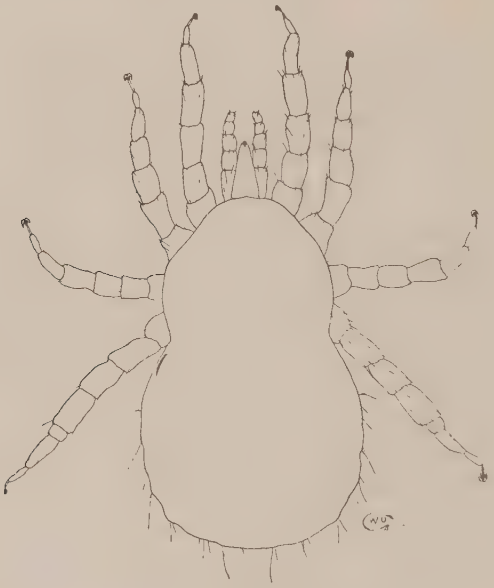


Fig. 113.—Chicken mite.

These mites sometimes attack man, but they are troublesome only where proper methods of control are not employed. The scaly leg mite is frequently a serious pest of chickens. It attacks the scales on the legs and in serious cases causes the leg to become deformed. It may be controlled by dipping the legs in kerosene.

Many species of mites are predators on insects, especially on scale insects, flies, beetles and grasshoppers, and are of value in keeping injurious insects in control. The water mites are an interesting group of mites. The larvæ are commonly parasitic on aquatic insects and the adults are free-swimming. Many of the adults are beautiful microscopic objects with long-fringed legs and brilliant colors.

CLASS MYRIAPODA.

The animals of this class are distinguished from the other common Arthropoda by the fact that their bodies are elongate, cylindric or worm-like in shape with two definite regions, a head and a trunk. The head bears a pair of antennæ and a pair of mandibles. The trunk is made up of several distinct segments. Each segment usually bears one (centipeds) or two (millipeds) pairs of legs.

Some Common Millipeds.—Most of our native millipeds are small, less than 1 inch in length; a few are minute, from $\frac{1}{5}$ to $\frac{1}{10}$ inch. A few, however, are much larger (Fig. 114). *Spirobolus marginatus* is one of the largest species, sometimes reaching a length of 4 inches. It is dark mahogany-brown with each segment marked with red. The feet and antennæ are reddish. It is common under logs in the eastern United States. *Fontaria virginiensis* is another large species found in the same situation. It is light brown in color with two lateral stripes of yellow. It has a rather pleasant odor resembling vanilla.

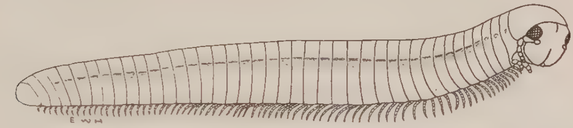


FIG. 114.—Millipede. *Spirobolus marginatus.*

Some Common Centipeds.—We have but a few species of centipeds in this country. Most of the species are small and live under stones and logs. They are quick, active animals and are seldom seen unless searched for. The species of the genus *Lithobius* (Fig. 115) are about 1 inch long. The body is composed of nine long segments and six short segments. The short segments are about one-fourth as long as the long segments. This gives the animals a very peculiar appearance.

The species of the genus *Linotænia* are from 1 to $1\frac{1}{2}$ inches in length, yellow or reddish-brown, often very abundant under bark of dead trees, fallen logs and stumps. They have about fifty legs. The *Geophilus rubens* is a larger species, nearly 2 inches in length, with the back marked by two broad bands of black. Our largest species of centiped is the *Scolopendra heros*, which reaches a length of 3 inches or more. It is yellowish in color and has twenty-one pairs of legs about as long as the width of the segment. It is distinctly southern in its distribution and belongs to the same genus as the very large tropical centipeds which are said to inflict a very serious bite. The house centiped, *Scutigera forceps* (Fig. 116), is the best-known species. It frequents houses in search of cockroaches and other insects. It is chiefly nocturnal, but frequently drops into sinks, wash bowls and bath-tubs, where it cannot escape. It is commonly called the earwig, but this name should be reserved for the insects belonging to the Order *Dermaptera*. The house centiped is much feared by most folks and not without reason, as its bite is very painful and causes considerable swelling and other troublesome after-effects. Its body is short, about 1 inch long, with fifteen segments, fifteen long legs and long antennæ. The antennæ are longer than the body and the last pair of legs nearly twice as long.

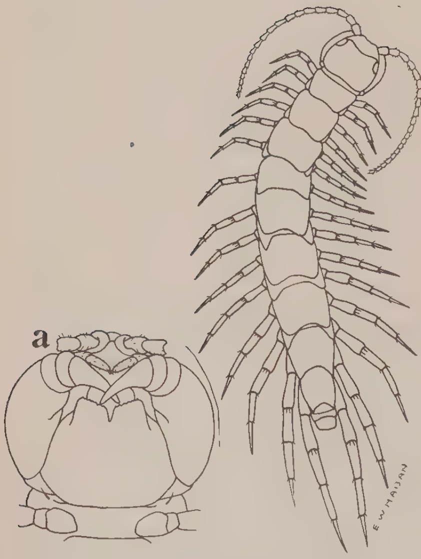


FIG. 115.—Centipede. *Lithobius multidentatus.* *a*, mouthparts showing mandibles.

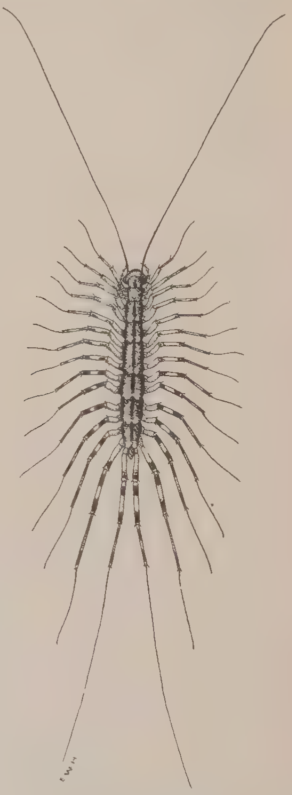


FIG. 116.—House centipede. *Scutigera forceps.*

THE POISONOUS ARACHNIDA AND MYRIAPODA.

While the arachnids and myriapods are not closely related, they have one thing in common. Most people believe that all the larger forms, at least, are dangerously poisonous. While it is true that the very largest species of these groups should be handled with respect, it is perhaps not amiss to emphasize the fact that only a very few of our species can really injure man. Most species of ticks can inflict painful bites and one species transmits a disease that is fatal in a large percentage of the cases. The itch mites are loathsome parasites. The bites of the larger centipeds and the house centipeds are painful but not dangerous. True scorpions are not common enough in this country to be considered as serious pests, and the sting of our small species is painful but not fatal. Most of the spiders cannot bite man, as their jaws work laterally and are not capable of piercing the human skin. There is one species of spider, the black widow, or hour-glass spider, that inflicts a painful bite accompanied by serious though not fatal after-effects. This is the common black spider that lives under stones, the loose bark of fallen logs and similar situations. The cephalothorax is small, the abdomen is large and spherical and is marked with bright red. There is usually a conspicuous spot shaped like an hour-glass on the underside of the abdomen. This spider is generally known and much feared. In the true tarantulas the jaws work vertically and can pierce the skin much more readily than the jaws of the true spiders. On this account they should be handled with respect, although it is very doubtful if the bite of the tarantulas is ever fatal to man. Many of the large spiders are known as tarantulas. The banana spider, a tropical species, frequently shipped into this country in bunches of bananas is an example. It is generally feared but authentic cases of bites are unknown. For the sake of emphasis, it might be restated that most of our arachnids and myriapods are harmless creatures. This reëmphasis is necessary because there is so much popular misinformation about these little creatures. The harmless character of all the millipeds, most of the centipeds, all the harvestmen, many of the mites, all the pseudoscorpions and practically all the spiders has been established in spite of the many popular superstitions to the contrary.

CHAPTER VIII.

THE INSECTS IN RELATION TO MAN.

(Class Insecta.)

Structure of a Typical Insect
Classification
  Aptera
  Orthoptera
  Neuroptera
  Hemiptera
  Coleoptera
  Lepidoptera
  Diptera
  Hymenoptera
Insects Beneficial to Man
  Predaceous
  Parasitic
Insects Furnishing Products Useful to Man
  Honey bee
  Silkworm
  Lac insect
  Cochineal
Insects and Diseases
  House flies and typhoid
  Mosquitoes and malaria
Insects as Farm Pests
  Sucking insects of importance
  Chewing insects of importance
  Insect pests of stored grain
Household Insects
  Annoying insects
  Destroying food and other household stores
  Destroying clothes and carpets
  Biting and stinging insects
Insect Pests of Domestic Animals
Insect Control

STRUCTURE OF A TYPICAL INSECT.

An insect (Fig. 117) may be defined as an arthropodous animal whose body is divided into three parts, a head, a thorax and an abdomen. The head usually bears a pair of compound eyes, a pair of antennæ and three pairs of mouth parts which may be much modified. The thorax bears typically two pairs of wings, although in the flies there is only one pair, and many insects, such as the fleas, bedbugs, lice, some plant lice, female scales, worker and

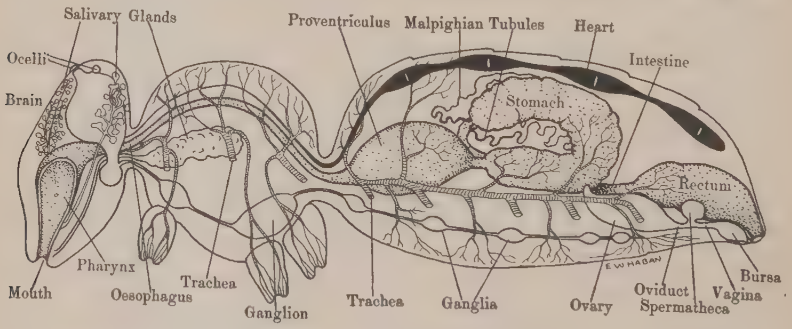

Salivary Glands
Proventriculus
Malpighian Tubules
Heart
Ocelli
Intestine
Brain
Stomach
Rectum
E W HABAN
Bursa
Mouth
Pharynx
Oesophagus
Trachea
Ganglion
Trachea
Ganglia
Ovary
Oviduct
Spermatheca
Vagina

Fig. 117.—Diagram of the structure of a typical insect.

soldier termites and worker ants are typically wingless. The thorax bears three pairs of legs. In the adult female scale insects legs are wanting. The abdomen is without external appendages, save the modified external genitalia located at the end of the abdomen.

The head is largely sensory in function and bears the compound eyes, simple eyes and antennæ. These will be discussed more in detail under sense organs. The head also bears the mouth parts which are among the most complicated structures found in the animal kingdom. Primitively, they consist of no less than three paired and three unpaired structures. We cannot inquire into the various morphological variations, but the following classification of the mouth parts of insects based largely on functional grounds will perhaps aid in conveying the complexity of the subject. We have, as our most generalized, the chewing insects (Fig. 118), which are fitted with a pair of mandibles which tear and masticate food.

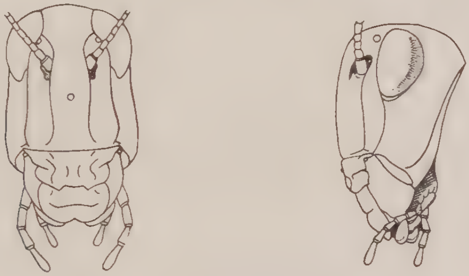


FIG. 118.—Types of insect mouth parts. The chewing type: the grasshopper.

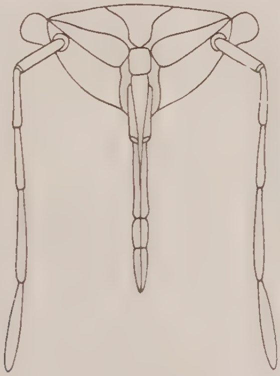


FIG. 119.—Types of insect mouth parts. Piercing type: the true bug.

A scraping type which lacerates the epidermis of plants and sucks up the exuding sap.

A piercing type (Figs. 119 and 120) in which the mouth parts are fitted for piercing the skin of an animal or the epidermis of a plant and sucking the blood or sap.

A rasping type (Fig. 121) fitted for rasping off solid particles and dissolving them in saliva and then sucking up the resultant liquid; or sponging type in which the mouth parts are fitted for sponging up exposed liquids.

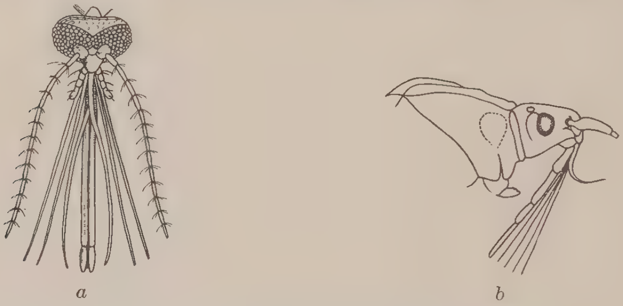


Fig. 120.—Types of insect mouth parts. *a*, piercing type of mosquito; *b*, piercing type of the true bug.

A siphoning type (Fig. 122) in which the mouth parts are formed into a long, hollow tube which is usually used to suck up exposed nectar.

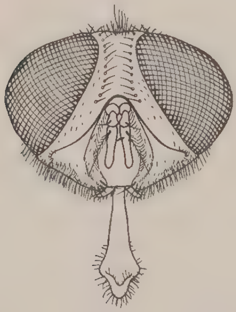


Fig. 121.—Types of insect mouth parts. Rasping type: the fly.

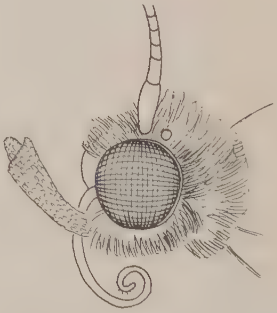


Fig. 122.—Types of insect mouth parts. Siphoning type: the moth.

A lapping type in which the mandibles are well developed for working wax and paper or for portage and the other mouth parts are modified into a tongue which is used to lap up exposed liquids.

The thorax is largely given over to locomotion, which is carried on by the wings and legs. The insects were without doubt the first animals to conquer the air, and of all animals, birds not even excepted, their mastery of the air is the most complete. The legs are fitted chiefly for walking, running, leaping and grasping. The speed of certain of our insects is indeed remarkable, as is their ability to make surprising leaps. The world's record for the broad jump is not held by a man but undoubtedly belongs to the flea. A leap of a hundred times his length would be no astounding feat for a flea, whereas for man five or six times his length would be wonderful indeed. In the same way the muscular strength of insects is almost beyond belief. The weakest insects, according to Plateau, can pull five times their own weight, while the average is more than twenty times, and one of the leaf beetles can pull forty-two times its own weight. In contrast, man cannot pull his own weight and under the same conditions a horse could pull but three-quarters of his weight. Some of the insects are able to push one hundred times their own weight, while the honey bee can carry a load equal to three-fourths of its bodily weight. These remarkable feats are accounted for by the small size of the insects and by the greater advantage in leverage from an external skeleton.

Passing to the internal organs we find time for the discussion of two systems of organs only. The first of these is the respiratory organs or tracheæ. The insects differ from man in that their circulatory organs are very poorly developed and their respiratory organs are well developed to counterbalance this. The insects have no lungs but a system of tracheæ or tubes which open to the exterior through minute pores called spiracles. From the spiracles the tracheæ branch and rebranch until they reach all parts of the body. The oxygen is carried to the cells through these tubes and the carbon dioxide carried away through the same set.

The nervous system and sense organs of insects are so different from those of man that we are often at a loss to account for the sensory life of insects. There is in the insects no brain as we find it in the vertebrates, but the nervous functions are distributed to a chain of ganglia along the ventral wall of the body. There is, therefore, more or less of local control for each region of the body. The psychic life of such animals is, therefore, rather low and in no way to be compared with that of man.

The sense organs of insects may be grouped into three classes (Comstock):

Mechanical sense organs—touch and hearing.
Chemical sense organs—taste and smell.
Organs of sight.

Touch organs are generally distributed over the body and need no special discussion. Organs of hearing are apparently not universally present. They occur among the singing orthoptera and in mosquitoes and perhaps in bees, but whether they occur in other forms is by no means clear. In the grasshopper the ears are located on the first segment of the abdomen, but in the katydids and crickets they occur on the tibia of the forelegs. In the mosquitoes they undoubtedly occur on the antennæ, as the antennæ are provided with whorls of setæ which gradually decrease in length from the base of the antennæ outward. It has been demonstrated that these setæ vibrate to notes of different pitch, and it is believed that the vibrations are transferred to the nerve endings. Most bee-keepers believe that bees can hear because they make such different hums under different circumstances, and even an amateur can tell the difference between the busy hum, the swarming hum and the angry hum of an outraged bee.

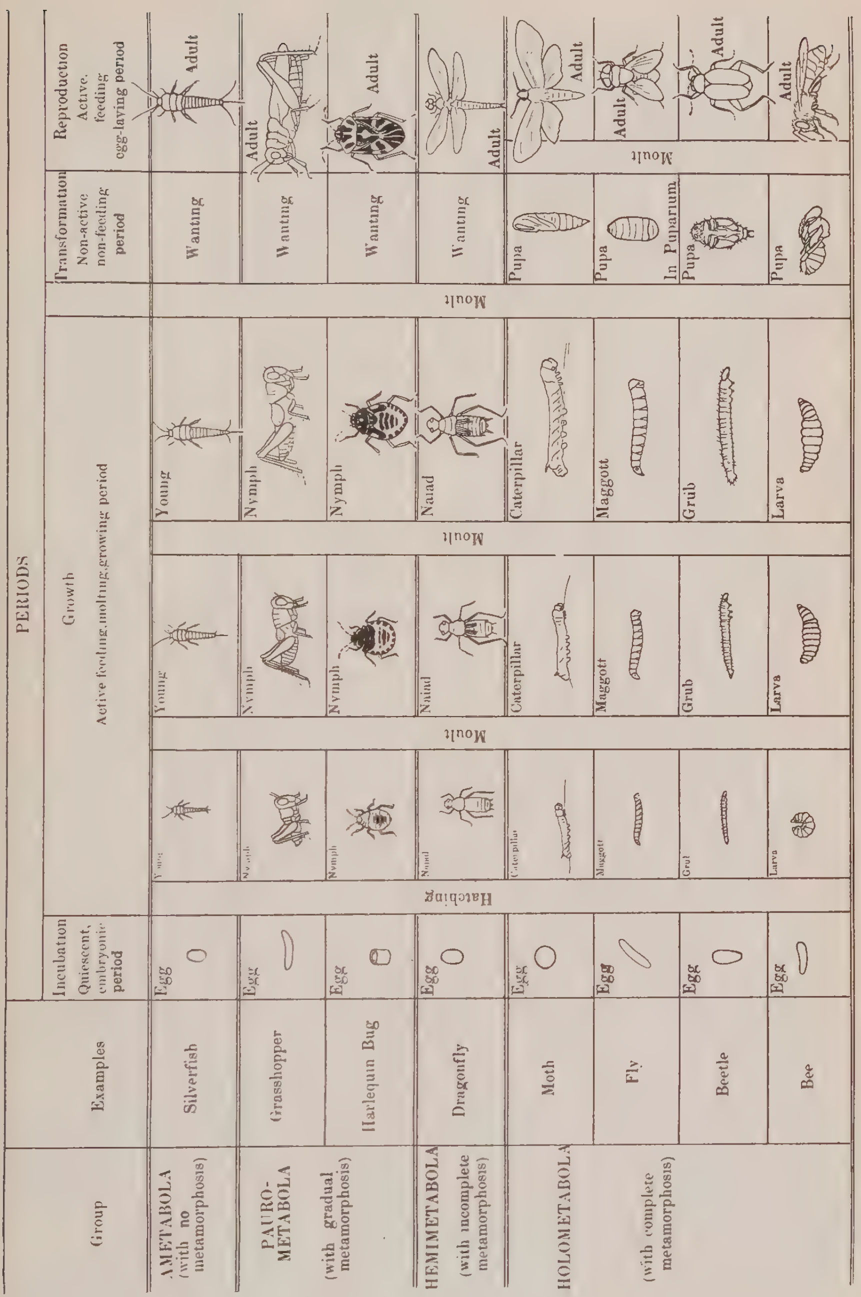
The chemical senses of insects are very poorly understood. This is due in part to the wide distribution of these organs over the body and to the fact that several different types of sense organs are frequently closely associated. We say that insects taste because we know they make selections in foods, and we say bees smell because they seem to be able to distinguish members of their own colony from other bees, and they seem to be able to recognize their queen and to distinguish drones.

The sense of sight in insects is taken care of by two distinct types of eyes, the simple eyes and the compound eyes. The former, we believe, is used chiefly to distinguish light from darkness, while the latter is used to give an image. The compound eyes of insects are composed of from a few to many hundreds of hexagonal prisms, called ommatidia. It is believed that each ommatidium forms a portion of the image just as tiles are put together to form a mosaic. Or, since the ommatidia are hexagonal in shape, perhaps we can best compare the image that insects receive to the image our eyes receive when we look through a piece of glass which has been laid down on poultry netting. Each mesh of the poultry netting would contribute its portion to the image just as each ommatidium of the insect's compound eye does. Obviously such an eye is better adapted to seeing motion than it is to seeing distinct images.

The wonders in the adaptations for carrying on the life cycle of insects are almost beyond belief. The time involved in completing a life cycle is apparently as varied as the species of insects themselves. There is the cicada, on the one hand, whose cycle covers seventeen years, while, on the other hand, we have the house fly with a complete cycle every nine to fourteen days, in the warmer parts of the year.

The complexity of the cycle is also very much involved. We have insects like the fish moth with no changes or metamorphosis on the one hand, while on the other we have forms like the blister beetles with no less than seven distinct stages in its cycle. Between these two extremes are all grades of forms with almost every conceivable relation.

The following diagram will make these relations clearer than they would otherwise be (Fig. 123).



		PERIODS					
Group	Examples	Incubation Quiescent, embryonic period	Growth Active feeding, molting, growing period			Transformation Non-active non-feeding period	Reproduction Active, feeding, egg-laying period
			Hatching	Moult	Moult	Moult	
AMETABOLA (with no metamorphosis)	Silverfish	Egg	Young	Young	Young	Wanting	Adult
PAURO-METABOLA (with gradual metamorphosis)	Grasshopper	Egg	Nymph	Nymph	Nymph	Wanting	Adult
	Harlequin Bug	Egg	Nymph	Nymph	Nymph	Wanting	Adult
HEMIMETABOLA (with incomplete metamorphosis)	Dragonfly	Egg	Naiad	Naiad	Naiad	Wanting	Adult
HOLOMETABOLA (with complete metamorphosis)	Moth	Egg	Caterpillar	Caterpillar	Caterpillar	Pupa	Moult Adult
	Fly	Egg	Maggott	Maggott	Maggott	Pupa In Puparium	Moult Adult
	Beetle	Egg	Grub	Grub	Grub	Pupa	Moult Adult
	Bee	Egg	Larva	Larva	Larva	Pupa	Moult Adult

FIG. 123.—Diagram of the metamorphosis of insects.

CLASSIFICATION.

In dealing with a class as large and as varied as the Insecta, it is a great deal better to divide them into smaller groups or orders for detailed consideration. Only the larger and more important orders can be considered here, and in a few cases several orders are considered together as a group.

Group Aptera.—The insects of this group are primitive, wingless forms without metamorphosis. Most of these forms are small and inconspicuous. They are known commonly as springtails and silverfish. The springtails (Fig. 124) are usually minute insects with the abdomen provided with an elaborate apparatus which enables them to leap often for a considerable distance. They live under leaves in the woods and similar moist situations. They will frequently be found collected on little pools of water early in the spring. These forms are of little economic importance. The silverfish (Fig. 125) occur in houses and are often troublesome pests, gnawing the labels from books, eating holes in clothing; in fact, eating anything that contains starch or glue.

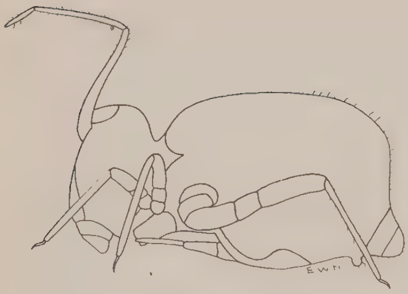


Fig. 124.—Springtail. (Author's illustration.)

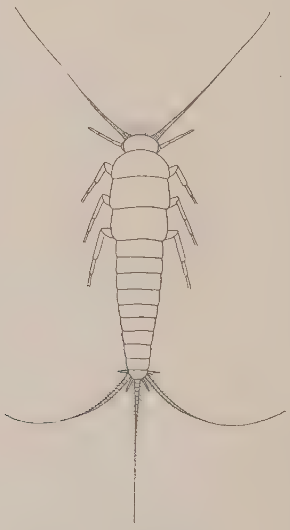


Fig. 125.—Silverfish. (Author's illustration.)

Order Orthoptera. This order includes such familiar forms as the roaches, or water bugs, the walking sticks, the preying mantids or devil's riding horse, the grasshoppers, the crickets and the katydids. These insects have the following points in common: They have direct metamorphosis, chewing mouth parts and usually two pairs of wings with the front pair somewhat leathery and the hind pair folded more or less like a fan.

The roaches, or water bugs (Fig. 126), are familiar to most city dwellers as pests in houses. They are oval, brownish or blackish bugs occurring in kitchens and pantries, especially about water pipes. They are also pests on board ships. They feed on various kinds of food, especially starchy foods like flour, meal and bread. The common species occurring in houses have been introduced into the United States from various parts of the world; the American roach from Central America, the Oriental roach from the Oriental region; the German roach or croton bug from Middle Europe. Our native roaches, comprising several species, live beneath the bark of dead trees and in similar situations.

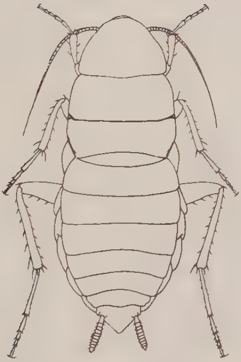


FIG. 126.—Roach. (Author's illustration.)

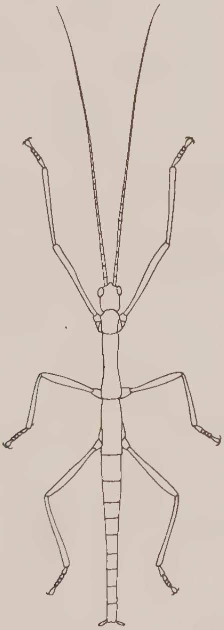


FIG. 127.—Walking stick. (Author's illustration.)

The walking sticks (Fig. 127) are slender, wingless insects that live in forests, feeding on the leaves of trees. In the tropical parts of the world there are closely related forms that are provided with wings and a broad body. These insects are known as leaf insects because of their general resemblances to leaves.

The praying mantid (Fig. 128) is an odd looking insect with powerful grasping front legs which it uses in capturing other insects and in holding the prey until it is devoured.

The grasshoppers (Fig. 129) or locusts are mostly heavy-bodied insects with short antennæ and powerful hind legs developed for leaping. They live in grass lands and weedy situations. The eggs are laid in the ground. Grasshoppers are frequently very destructive to cultivated crops, especially where farms are near large areas of uncultivated grasslands. Frequently they migrate in enormous numbers from uncultivated areas to cultivated areas, eating the crops as they migrate.

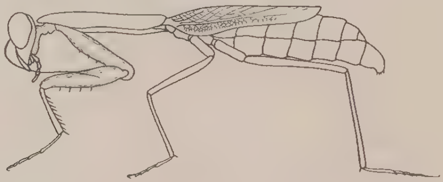


FIG. 128.—Praying mantid. (Author's illustration.)

The long-horned grasshoppers or katydids are particularly familiar because of the songs of certain species which resemble somewhat the syllables "katy-did, katy-did-n't." Many species of this group are musical and add much to the joy of peaceful summer evenings. Most of the species live in trees, shrubs or coarse weeds. Some of the species are wingless, living under stones, logs, in caves and similar situations. These are usually known as cave crickets.

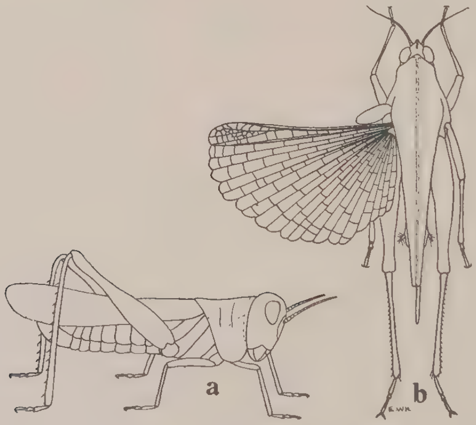


FIG. 129.—*a*, grasshopper; *b*, grouse locust. (Author's illustration.)

The true crickets are known as the field or brown crickets which live under stones in fields and gardens. Occasionally they invade houses, where their cheerful chirping adds a joyful note to autumn evenings by the fireside. The tree crickets are pale greenish-white crickets. The males have elaborately developed wings used in singing. The song consists of a rhythmic trill which may be continued for a long time. These insects live among shrubs and lay their eggs in the twigs of various plants. They are frequently brought into houses with cut flowers, where their singing attracts attention. The mole crickets (Fig. 130) are heavy-bodied and brownish in color with the forelegs powerfully developed for burrowing beneath the soil like a mole.

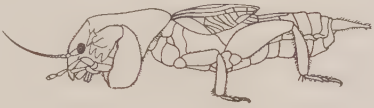


FIG. 130.—Mole cricket. (Author's illustration.)

Group Neuroptera.—This group includes a large number of insects of various habits. These are not closely related, but most of them have one thing in common—they are usually provided with two pairs of wings with many veins and cross-veins. The most conspicuous members of this group are the dragonflies and damsel flies, *Order Odonata,* which are sometimes called mosquito hawks or snake doctors. The dragonflies (Fig. 131) are among the swiftest and most graceful of all the flying insects. They capture their prey while on the wing, which consists for the most part of small flies, gnats and mosquitoes; therefore these insects must be very agile. The eyes are likewise enormously developed. The damsel flies are smaller than the dragonflies. Their wings are not so well developed and they spend most of their time in the grasses and

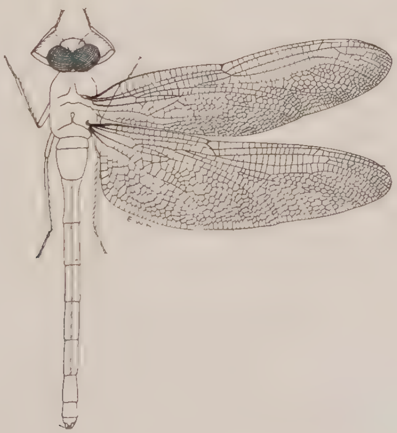


FIG. 131.—Dragonfly. (Author's illustration.)

rushes around lakes and ponds. The nymphs (naiads) of both the damsel flies and the dragonflies are predaceous and aquatic.

The May flies, *Order Ephemerida,* are delicate neuropterous insects. The nymphs (naiads) live in water and require one to three years to complete their development. In contrast the adults live for only a few days, being without mouth parts and incapable of feeding. In the Great Lakes region May flies often emerge in enormous swarms, and since they are attracted to lights they often become a nuisance about street lights, store fronts and on the sidewalk.

The termites, or white ants, *Order Isoptera* (Fig. 132), are interesting colonial insects. Our species live in wood and frequently do extensive damage by tunneling through timbers in buildings and by destroying books stored in basements. A colony usually consists of kings and queens, true reproductive males and females; of workers, that perform the usual duties of caring for the young, providing food, etc.; and of soldiers, individuals with large heads and mandibles.

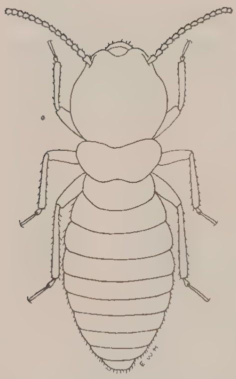


Fig. 132.—Termite. (Author's illustration.)

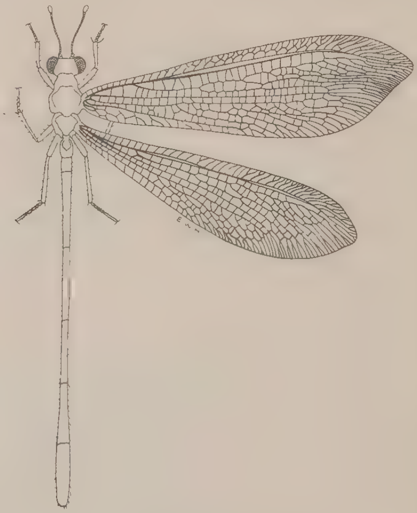


Fig. 133.—Ant lion. (Author's illustration.)

The aphis lions and the ant lions, *Order Neuroptera* (Fig. 133), especially the nymphs, are familiar to most people. The nymphs of aphis lions are found on plants of various kinds in the summer time. They are slender-bodied little fellows with enormous sickle-shaped jaws with which they seize aphids and other soft-bodied insects and suck out their body fluids. The adults are beautiful slender insects with large gauze-like wings and metallic golden eyes. Unfortunately these insects have a very disagreeable odor. The nymphs of the ant lions construct funnel-shaped tunnels in sand. They lie at the apex of the funnel and wait for some luckless ant to tumble into the trap. When an insect walks into the trap the nymph throws sand over it to hasten its descent. The adults of these insects are slender-bodied, elongate insects with two pairs of large wings with many veins and cross-veins.

There are two kinds of lice, the chewing lice or bird lice, *Order Mallophaga* (Fig. 134), and the sucking lice, *Order Anoplura* (Fig. 135). The former have chewing mouth parts and live on the scales of the skin, bits of feathers, etc. These lice infest both birds and mammals. The chief injury they do is by setting up an intolerable itching. The sucking lice, as their name implies, suck blood from their hosts. They infest mammals only. Most kinds of domestic animals harbor one or more species of lice. There are three kinds that are pests of man—the head louse, the body louse and the crab louse. The head louse lives generally on the head, fastening its eggs to the hair. The body louse lives principally on the body, attaching its eggs to the clothing. The crab louse lives among the coarse hairs of the body. All three kinds became very abundant during the World War and were known generally as "cooties."

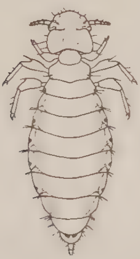


Fig. 134.—Bird louse. (Author's illustration.)

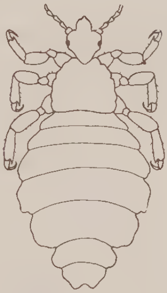


Fig. 135.—Sucking louse. (Author's illustration.)

Group Hemiptera.—This group includes the true bugs, such as the water striders, the bedbug, the chinch bug, the stink bugs and many others. All have piercing mouth parts and suck the sap from plants or blood from animals. If wings are present there are usually two pairs. The front pair is thick at the base and thin and overlapping at the tip. The metamorphosis is gradual, the nymphs resembling the adults to a considerable extent.

The water striders (Fig. 136) are familiar to most people. They have two pairs of long legs, the front pair being shorter, and they walk about on the surface of the water.

The chinch bug is a well-known pest of corn and small grains.

It is about $\frac{1}{6}$ inch long and often swarms in countless millions from fields of small grains to corn fields. Fortunately it does not usually fly, and may be readily checked in its migrations by dust or creosote barriers placed between the two fields.

Most of the true bugs secrete a foul-smelling substance, but people generally are more familiar with the small stink bugs which occur commonly on berries of various kinds, giving them a strong unpleasant odor.

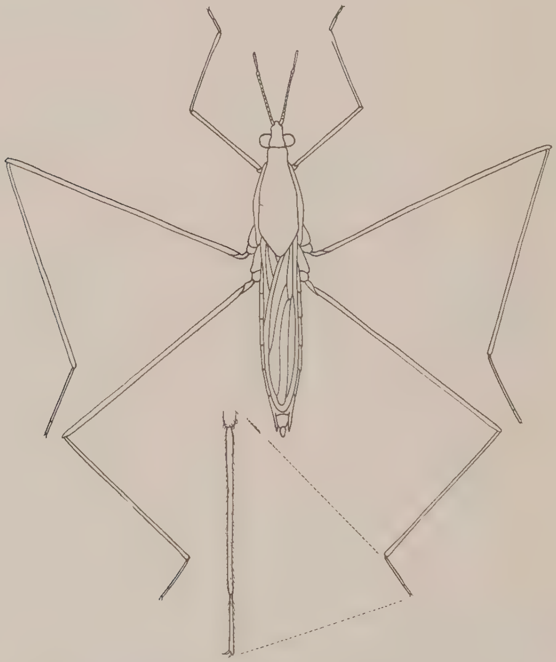


FIG. 136.—Water strider. (Author's illustration.)

The bedbug is an unpleasant parasite of man of almost world-wide distribution, infesting beds and making nights hideous by its painful bites. Fortunately, ordinary sanitation will practically eliminate this pest.

The *Order Homoptera* includes the cicadas, sometimes called locusts, or July flies, the leaf hoppers, the tree hoppers, the plant hoppers, the plant lice, the scale insects and the white flies. The members of this order have piercing mouth parts and usually two pairs of wings. Sometimes the first pair is thin and membranous, sometimes thick and leathery. The metamorphosis is gradual. This order contains some of our most troublesome plant pests.

The cicadas (Fig. 137) are interesting insects. They occur in practically all parts of the world. The males are provided with an elaborate sound-producing apparatus, which consists of a tight membrane stretched across a cavity with a muscle attached to its center which produces the vibrations much after the manner of a small boy who fastens a string to the bottom of a tin can and then produces a noise by pulling on the string. The sound is usually modified by elaborate sounding plates. The sounding apparatus occurs only in the male, and would seem to be for the purpose of attracting the female. The cicadas also include the famous seventeen-year cicada. This insect requires thirteen or seventeen years to complete the process of metamorphosis. The more southern races require thirteen years (Fig. 138) and the more northern races

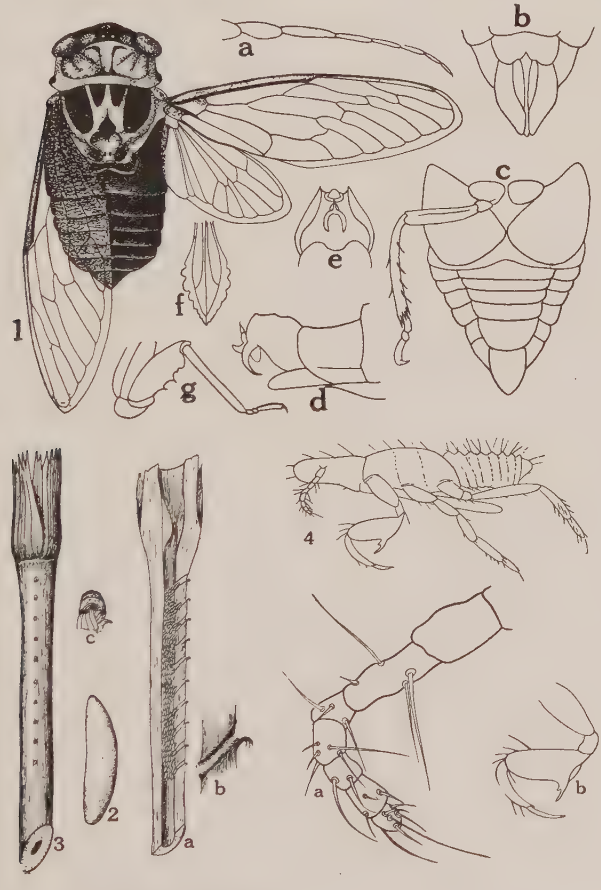


Fig. 137.—Cicada. (Author's illustration.)

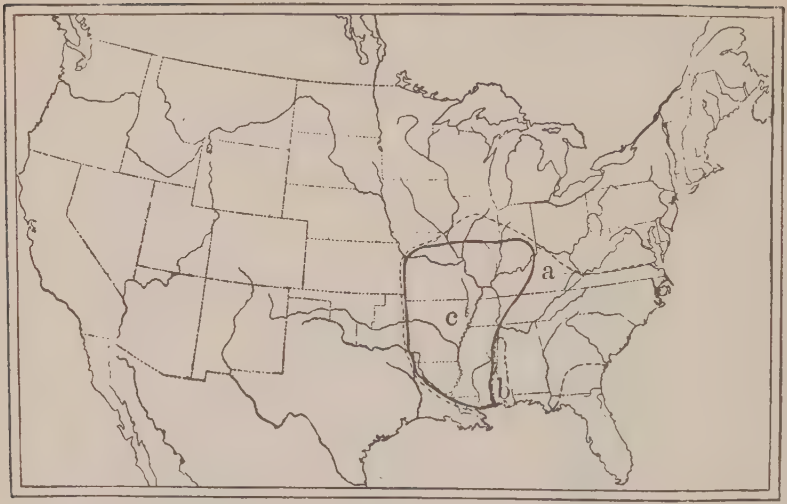


FIG. 138.—Map showing the distribution of the broods of the thirteen-year cicada. *a*, Brood 19, 1933. Generally distributed. *b*, Brood 21, 1935. *c*, Brood 23, 1937.

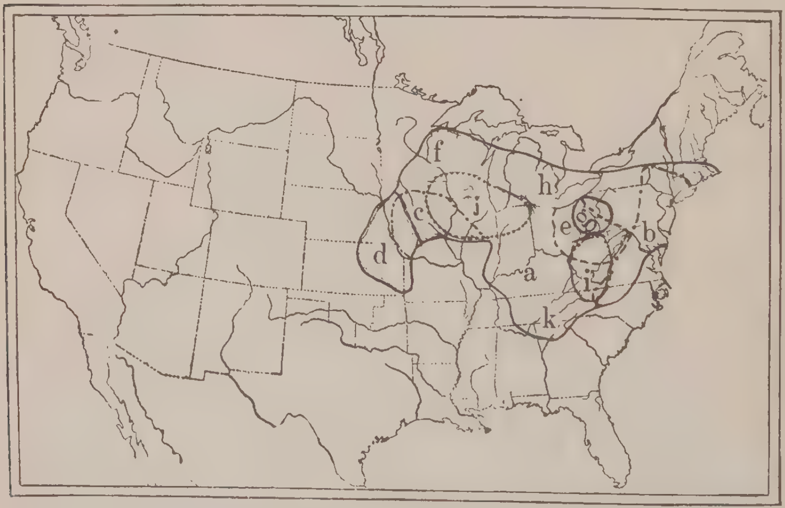


FIG. 139.—Map showing the distribution of the seventeen-year cicada. *a*, general distribution; *b*, Brood 2, 1945; *c*, Brood 3, 1946; *d*, Brood 4, 1947; *e*, Brood 5, 1931; *f*, Brood 6, 1932 (generally distributed east of the Mississippi River); *g*, Brood 8, 1934; *h*, Brood 10, 1936 (generally distributed east of the Mississippi River); *i*, Brood 9, 1935; *j*, Brood 13, 1937; *k*, Brood 14, 1940 (generally distributed east of the Mississippi River).

seventeen years (Fig. 139) for a generation. There are a number of different broods in the eastern United States. Thus, Brood VI occurred from northern Georgia to New York and westward to

Illinois and Wisconsin in 1915. It will not appear again until 1932. Brood X occupies about the same territory it occurred in 1919 and will appear again in 1936. Brood XIX of the thirteen-year race appeared from southern Illinois to Louisiana and eastward to North Carolina in 1920. It will appear again in 1933. Brood XXIII of the thirteen-year race appeared in the Mississippi Valley in 1924. It will appear again in 1937. These represent some of the larger broods. There are smaller broods in different parts of the country.

The tree hoppers (Fig. 140) live primarily on trees and shrubs. They are noted especially for the elaborate development of the prothorax, which may be variously modified into spines, horns and balls. Most of these insects have a very droll look and have been called insect brownies. Very few of the species are ever abundant enough to do any very serious damage.

The leaf hoppers (Fig. 141) are small triangular insects abundant on grasses and other herbaceous plants. Some species are very destructive, for example, the bean-leaf hopper, which feeds not only on beans, but on potatoes, peanuts, etc. The beet leaf hopper is destructive to the sugar beet in the West. The grape-leaf hopper is one of the most destructive pests of grapes. While many species are destructive to clover, grasses and small grains. The plant hoppers are sometimes called lantern flies, although this is a misnomer as none of the species normally produce light. They are mostly small forms, but some of the tropical species are rather large. They are noted for the peculiar modifications of the head and wings. This family contains some of the most bizarre insects known. None of the forms are of any great economic importance in this country. But a species of this family nearly ruined the sugar-cane industry in Hawaii and a closely related species is very destructive to sugar cane in the West Indies.

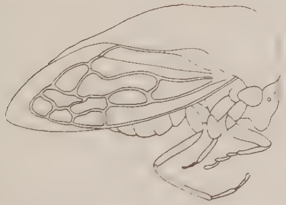


FIG. 140.—Tree hopper. (Author's illustration.)

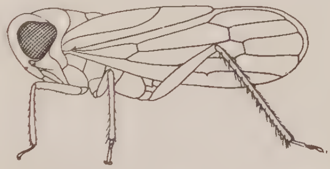


FIG. 141.—Leaf hopper. (Author's illustration.)

The plant lice (Fig. 142) include some of our most destructive plant pests. Their life histories are often quite complicated as agamic and true sexual forms often occur in the same species, either one or both these forms may have both winged and wingless forms and a migration from one host plant to another may also occur to further complicate matters. A typical life history would be about as follows: True males and females appear in the fall, mate and the female lays eggs which remain over winter. In the spring these eggs hatch into wingless agamic females which give birth to living young without being fertilized. There may be several generations of wingless agamic females in this way, but eventually winged agamic females are developed which migrate to the secondary host. Several generations of wingless agamic females may be produced on the secondary host, but eventually winged agamic females are produced which migrate to the primary host and produce true males and females which mate and the females lay overwintering eggs. Plant lice injure plants by sucking the sap. Some species produce galls on leaves, twigs or roots. Because of the great rapidity with which they breed, plant lice often increase to destructive numbers in spite of a number of parasites and predators.

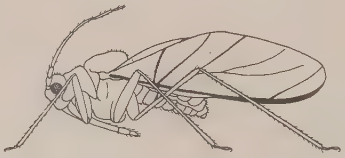


Fig. 142.—Plant louse. (Author's illustration.)

The scale insects (Fig. 143) are likewise exceedingly destructive to plant life and rank among the foremost pests of shade and fruit trees. Because of their small size they may be easily overlooked, and in this way they have been transported from various parts of the globe along with introduced plants. They are called scale insects because the adult female typically lives between two wax-like scale coverings. The protection afforded by the scale covering makes these insects difficult to control. Since they normally have several generations in a year and a single female often produces a hundred or more young, they frequently increase at an enormous rate and will often completely encrust a tree in a year or two. The life history of a typical scale insect is interesting because the history of the female is so different from the history of the male. The female lays eggs or gives birth to living young. These young are provided with three pairs of legs and crawl about until they find a suitable place to lodge when they insert the beak and commence to suck the sap. After a short time they moult, losing the legs, eyes and antennæ. If the young develops into a female it does not move after it becomes located but secretes a double scale covering which protects it dorsally and ventrally. If the young develops into a male it goes through a different metamorphosis, eventually becom-

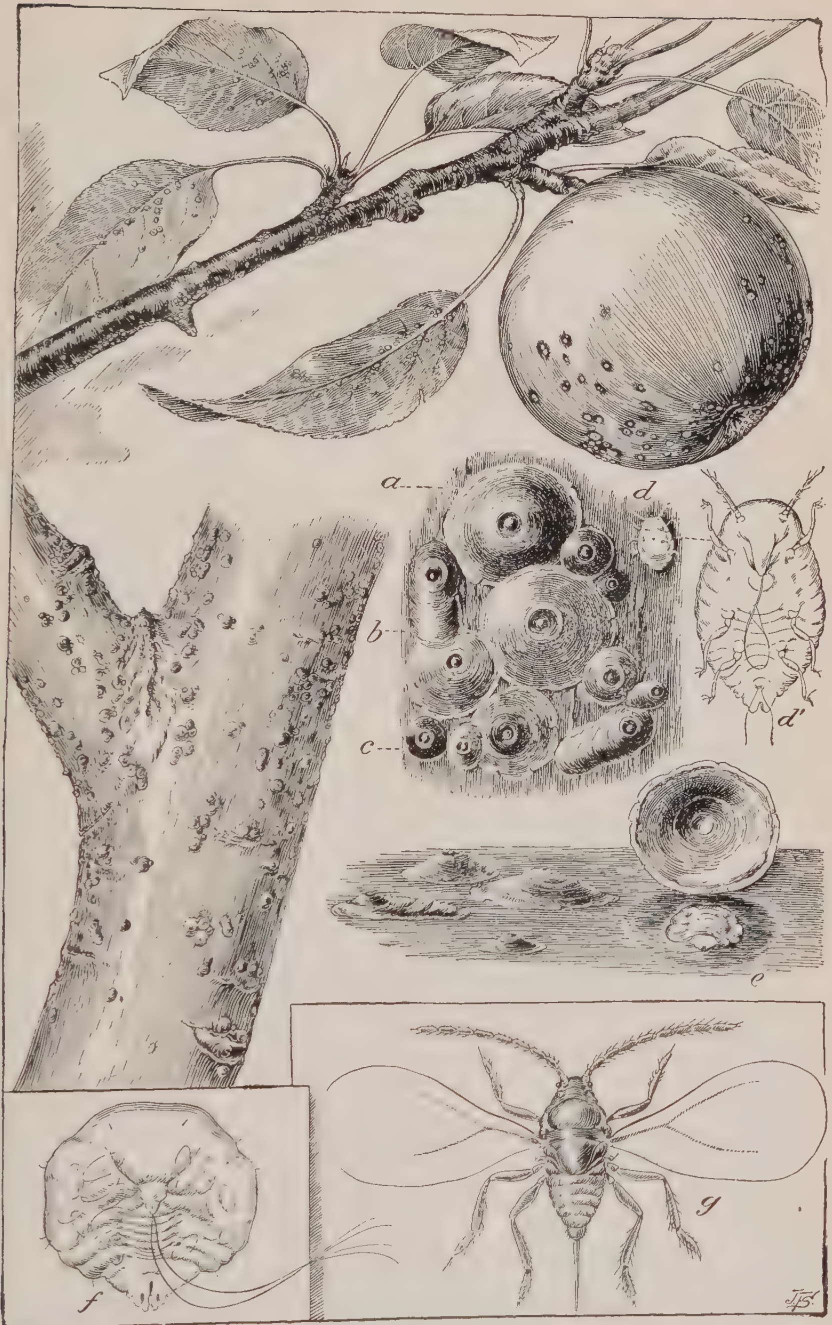

a
b
c
d
d'
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FIG. 143.—San José scale. (U. S. Dept. of Agriculture.)

ing a tiny gnat-like insect with a single pair of wings, three pairs of legs, a pair of antennæ and two pairs of eyes but no mouth parts. The males then seek out the females with which they mate and then die. Scale insects may be controlled by applying emulsions of oils or lime-sulphur washes to the trees during the dormant season.

Order Coleoptera.—This order contains the beetles and the snout beetles. This is one of the largest orders of insects. The adults are usually provided with two pairs of wings. The front pair is hard and horny and typically they fold over the abdomen, covering it and the thin hind wings like a shield. The metamorphosis is complete and both adults and larvæ have chewing mouth parts. Some of the most destructive pests of agriculture are included in this order. Only the more interesting forms can be discussed here.

The tiger beetles (Fig. 144) and ground beetles are predaceous insects living on the ground and feeding on such insects as they can can overpower. The whirligig beetles live in quiet pools in streams and along the banks of ponds and lakes. They are seldom quiet for any length of time, but gather in schools and carry on a most elaborate dance which is familiar to every one and too intricate to describe.

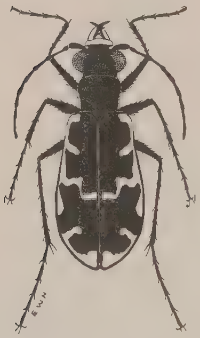


FIG. 144.—Tiger beetle. (Author's illustration.)

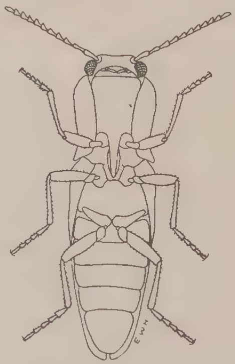


FIG. 145.—Click beetle. (Author's illustration.)

The fireflies or lightning bugs are familiar to all children, as they delight to capture these interesting creatures on a summer evening and hold them in their hands or place them in a bottle to see them flash their tiny lamps. The light of the firefly is interesting because it is one of the most perfect lights known, that is to say, that practically all of the energy released is converted into light, whereas in man-made lights only a small part of the energy is converted into light, the larger percentage being converted into heat. These flashes enable these insects to find their mates.

The click beetles or jack snappers (Fig. 145) are well-known insects because they have the habit, when placed on the back, of giving a snap which throws them into the air a few inches. This usually enables the insect to turn itself over and land on its feet. This habit is used by these insects to escape their enemies. If an enemy approaches a click beetle it falls to the ground as if dead. After a time it gives a snap and if it lands on its feet it runs away. The larvæ of the click beetles are known as wireworms, because they are elongate cylindric worms with rather hard skins. Some wireworms live on the roots of grasses in sod land; if this sod land is plowed and planted in corn the wireworms are destructive to the corn by eating the roots of the young plants.

The lady beetles, or lady birds (Fig. 146), and their larvæ are commonly predaceous. Some kinds, especially the small species that are black with red or yellow spots, feed on scale insects, while others, especially the larger species that are reddish or yellowish with black spots, feed on plant lice. They are, therefore, often of much benefit to the farmer. The adults are well known, as children are in the habit of capturing them and while holding them in the hand repeat the jingle:

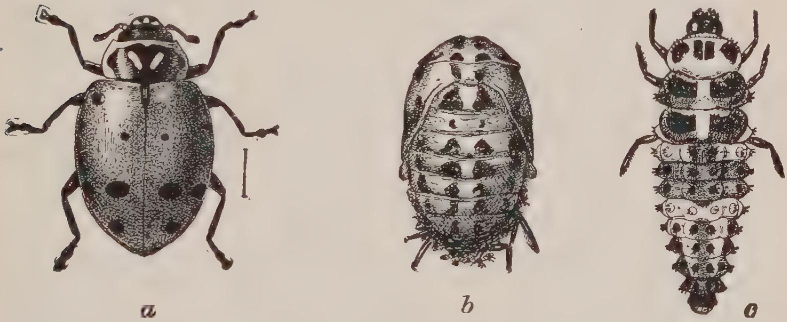


FIG. 146.—Lady beetle. *a*, adult; *b*, pupa; *c*, larva. (U. S. Dept. of Agriculture.)

"Lady bird, lady bird, fly away home,
Your house is on fire, your children will burn."

When the hand is opened the accommodating lady bird flies away home. A few of the lady beetles feed on plants, the squash lady beetle on squashes and the Mexican bean beetle on beans are familiar examples.

The longhorned beetles (Fig. 147) are beetles with very long antennæ. Sometimes the antennæ are several times as long as the body. The larvæ are round-headed borers and occur in trees of various kinds, boring round holes through the trunk or limbs.

The flat-headed borers belonging to another family commonly bore oval holes, especially in the sap wood of trees and shrubs. The adults of this group are usually oval, flattened beetles with bright metallic luster. Some of the tropical forms are brilliant, often showing reflections of blue, green, purple and scarlet or gold.

The bean and pea weevils (Fig. 148) are an interesting group of small beetles that feed on the seeds of beans, peas, cow-peas and related plants. The eggs are laid on the outside of the seeds, sometimes simply scattered among the seeds and sometimes glued to the outside of the seed. The young larva eats its way into the seed, and when it becomes full grown eats its way to the surface, where it cuts a small window in the outer skin of the seed and then pupates. When the adult emerges it pushes the window out and leaves a neat, round hole.

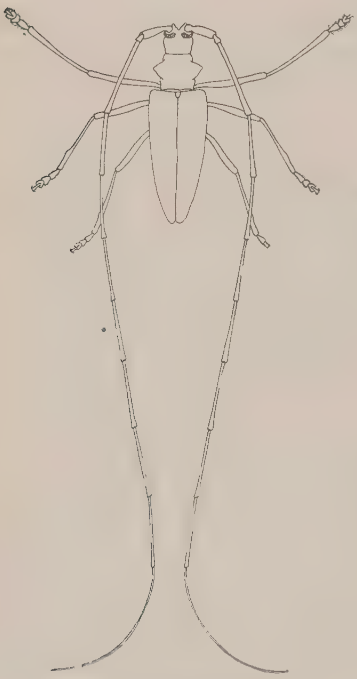


Fig. 147.—Longhorned beetle. (Author's illustration.)

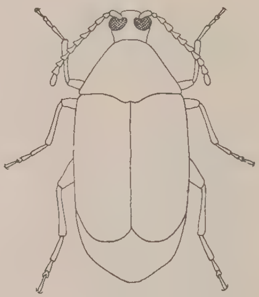


Fig. 148.—Cow-pea weevil. (Author's illustration.)

The leaf beetles (Fig. 149) constitute a large family of very destructive insects. As their name implies, they usually feed on the leaves of plants. The larvæ sometimes feed on the leaves of the same plant with the adults; sometimes they are found on the roots of the same plant or sometimes of other plants. This family contains many destructive insects, such as the Colorado potato beetle, flea beetle, cucumber beetle and corn-root worm.

The tumble bugs and the leaf chafers are stout-bodied beetles. The tumble bugs are familiar because of their habit of rolling up a ball of dung and burying it in the ground as food for their larvæ. The leaf chafers, also known as May beetles and June bugs, live as larvæ on the roots of grasses. These are usually known as grub worms or white grubs. The adults feed on the leaves of trees and on fruits. They are the heavy-bodied green or brown beetles that come buzzing about lights in the late spring or early summer.

The snout beetles (Fig. 150) are small beetles with the head drawn out into a long snout. This snout may be longer than the body, as in the nut weevils. These beetles feed on fruits and nuts. The larvæ develop in the fruit or seed pods and are frequently very destructive. The curculio, which causes wormy peaches and plums, the destructive cotton boll-weevil, the strawberry weevil, the granary weevils and others belong to this group.

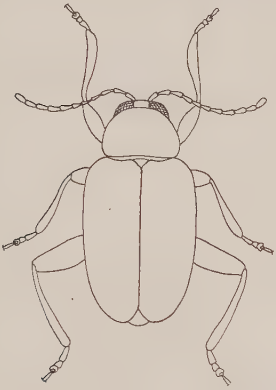


FIG. 149.—Leaf beetle. (Author's illustration.)

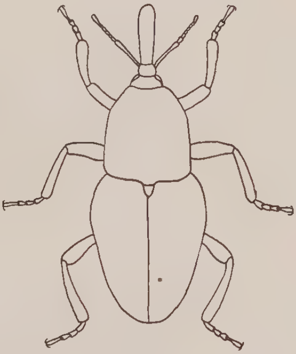


FIG. 150.—Snout beetle. (Author's illustration.)

Order Lepidoptera.—The butterflies and moths belong to this order. The adults have the body and wings covered with scales. These scales are frequently bright colored and arranged in odd patterns. The metamorphosis is complete and the larvæ are usually known as worms and caterpillars, and the pupæ as chrysalids or cocoons. The larvæ have chewing mouth parts and are frequently very destructive. The adults have a long proboscis and suck nectar from flowers. This is a very large order, but only a few of the more interesting forms can be discussed.

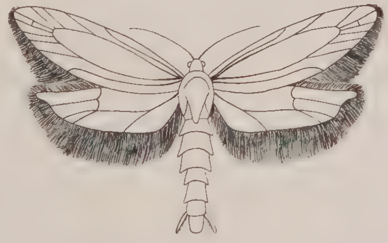


FIG. 151.—Microlepidoptera. (Author's illustration.)

Many of the forms are small or even minute. These are known as the Microlepidoptera (Fig. 151). Some of the forms are so tiny that the larvæ can live between the upper and under surface of the leaves. These are known as leaf miners. The micros also include the codling moth, which lays the eggs that develop into the worm that produces wormy apples, and the clothes moths, which are often destructive to woolen clothes and feathers.

Measuring worms are well known. They feed on the leaves of trees and shrubs. Their bodies are elongate with legs both fore and aft, but not amidship. They travel, therefore, with a peculiar looping motion. The hind legs are fastened and the body extended, often after exploring in all directions, and the front legs fastened. The hind legs are then drawn up close to the front legs and the process repeated. The larvæ have the habit of fastening a silk thread and dropping to the ground when disturbed. The adults are slender-bodied, broad-winged moths, often greenish in color.

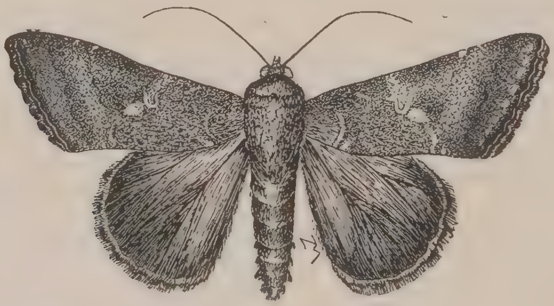


FIG. 152.—Miller. (Author's illustration.)

The dusty millers, or millers (Fig. 152), are grayish-brown moths, about 1 or 2 inches across the outstretched wings. They have the habit of coming to lights at night and are familiar to nearly everyone. Their larvæ are the common cutworms, which are so destructive to garden and field crops.

The silkworm has been cultivated in the Oriental countries for centuries for the fine silk threads it produces. More recently the cultivation of silk has been carried on in France, Italy and other European countries. Silk culture has been tried a number of times in America but has never been profitable. We have also a group of large striking moths that may be known as the giant silkworms. Some of our most beautiful moths belong to this group.

Another group that contains large moths is the hawk moth family (Fig. 153). These moths are sometimes known as humming-bird moths because they resemble humming-birds as they visit flowers to get nectar. The larvæ are usually large green worms, with

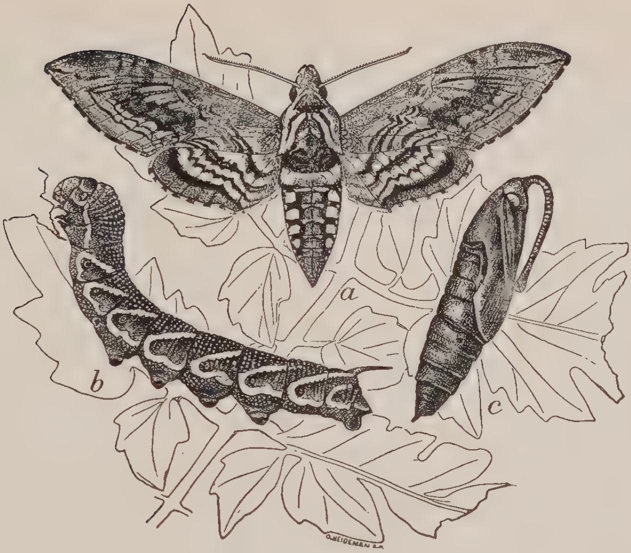
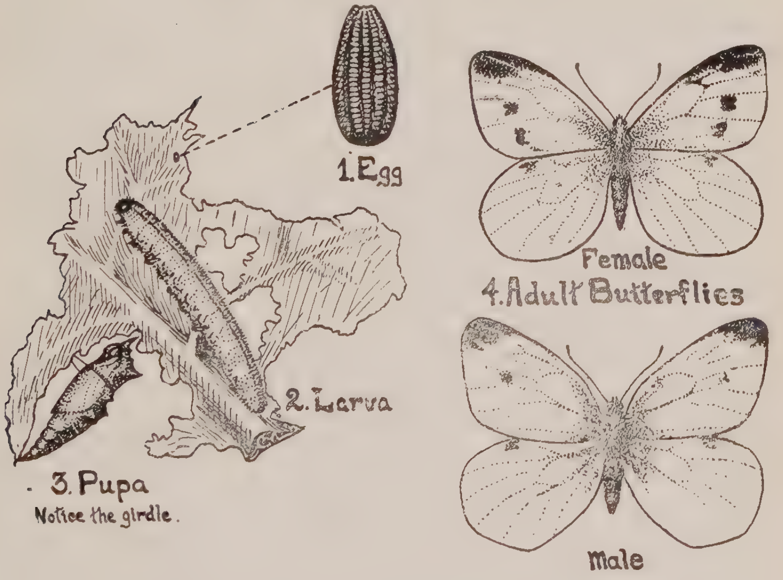


FIG. 153.—Hawk moth. (U. S. Dept. of Agriculture.)

IMPORTED CABBAGE BUTTERFLY

The four successive stages of its life


1. Egg
Female
4. Adult Butterflies
2. Larva
3. Pupa
Notice the girdle.
Male

All about natural size except "1. Egg," which is much enlarged

FIG. 154.—Cabbage butterfly. (C. L. Metcalf.)

a spine on the posterior end of the body. The tobacco or tomato worms are familiar examples. The pupæ are known as pitchers because the long tongue case is bent away from the body like the handle of a pitcher.

The butterflies are well known to everyone because of their bright colors. They may be classified as swallow-tails, whites, yellows, blues and browns. The swallow-tail butterflies are large butterflies, black and yellow or bluish-black in color with the hind wings produced into long tails. The common cabbage butterfly (Fig. 154) belongs to the whites. The larva of this butterfly is one of the most destructive pests of cabbage and related crops. The yellows are usually yellow in color with the wings bordered with black. Some species have the habit of collecting in great numbers about mud puddles in the summertime. The blues are small butterflies with bluish or coppery reflections. The browns are usually large butterflies, more or less marked with brown. Some of the species have the wing margins notched and are known as angle wings.

Order Siphonoptera.—The fleas are small wingless insects with piercing mouth parts. They live as parasites on various animals, the common cat and dog flea being familiar to everyone who has kept these pets. The metamorphosis is complete. The eggs are scattered about and the larvæ feed on the dust and dirt in cracks in the floor.

Order Diptera.—This order includes the flies, gnats and mosquitoes. They have only one pair of wings, a few forms being wingless and piercing or sponging mouth parts. The metamorphosis is complete.

The mosquitoes (Fig. 160) are well known because of the annoying habit of biting. It is only the females that bite. The males live on nectar. The larvæ of the mosquitoes live in water and are known as wiggle tails. Mosquitoes are the transmitters of such diseases as malarial fever and yellow fever.

The other small diptera are usually known as gnats. Some are troublesome to man because of their bites. Among these are the buffalo gnats and the sand flies. The larvæ of some forms produce curious growth on plants and are known as gall gnats. This group also includes the Hessian fly which is so very destructive to wheat.

The flies as a group are chiefly annoying to man and his domestic animals. A few are parasites of domestic animals as the horse bot which lives in the stomach of the horse and the ox warble which produces the grubs in the backs of cattle. Some forms are very annoying to man and his domestic animals because they bite and suck blood. The horse flies, deer flies, stable fly and horn fly belong here. Some, like the house fly (Fig. 155) frequent fecal matter and carry intestinal diseases like typhoid fever. Some are parasitic on other insects and are very beneficial to man. Others are predaceous, feeding on other insects like the adults of the robber flies and the larvæ of the flower flies.

Order Hymenoptera.—This order includes the bees, ants and wasps. They generally have two pairs of membranous wings with few veins. The mouth parts are usually fitted for lapping with the jaws well developed for portage or defense. The metamorphosis is complete.

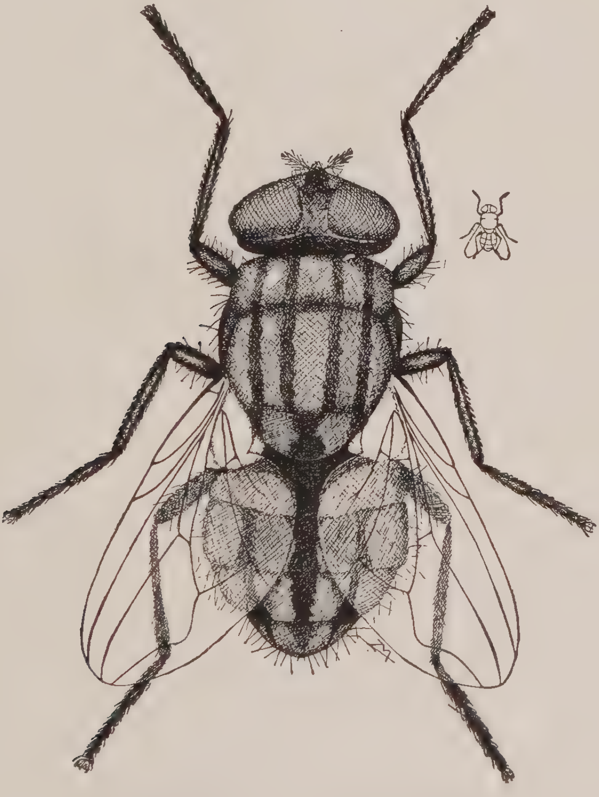


FIG. 155.—House fly. (Author's illustration.)

Many of the members of this order are social in their habits, often forming colonies of many thousands of individuals. There are, however, many solitary species. The order as a whole is beneficial. Many of the solitary species are parasitic on other insects, some preditators, while the bees are beneficial because they cross pollinate flowers.

The most interesting of the Hymenoptera are the social forms, like certain of the bees, ants (Fig. 156) and wasps. There are two kinds of social bees, the honey bees and the bumble bees. The honey bee has been domesticated for a long time. It was brought to this country by the early settlers. Many colonies have escaped to the woods and become established in hollow trees. Many other colonies are escaping each year so that it is popularly believed that there always have been wild bees in this country, but there were no honey bees in the woods before the advent of the white man. A colony consists of several males (drones), one developed female (queen) and several thousand undeveloped females (workers). The function of the males is to fertilize the young queens as they emerge. The function of the queen is to lay eggs for the colony. She is the mother of the colony, not the ruler. The workers perform the necessary labor of the colony. They secrete the wax and build it into combs of many six-sided cells. The cells are used to store honey and pollen and the queen lays eggs in these cells, and the larvæ are fed on honey in the cells by the workers until they are full grown. Nectar is collected from flowers by the workers and carried to the hive in the honey sac. After it is stored in the cells a large amount of water is evaporated from the nectar which is changed into honey.

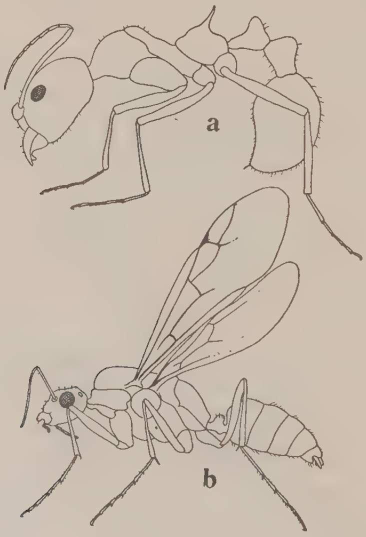


Fig. 156.—Ants. *a*, worker; *b*, queen. (Author's illustration.)

Pollen is also used as food by the developing larvæ. It is collected from the flowers and carried to the hive in the pollen baskets which are located on the hind legs. The workers also carry water to the hive as it is needed and propolis, or bee glue, which is collected from the buds of trees. The propolis is used to fill holes in the walls of the hive and for many other purposes. Workers also guard the hive against strange bees and other enemies. In fact, they are in a ceaseless round of activities from the time they emerge from their larval cells until they wear themselves out. Drones develop from unfertilized eggs. There are usually several drones in each colony. Both the queens and workers develop from fertilized eggs. The workers develop in ordinary six-sided cells and are fed on honey and pollen. The queens are raised in large cells shaped somewhat like a small peanut. The queen larvæ are fed on a special kind of food, the royal jelly.

The honey bee has long been a source of inspiration for poet and philosopher as well as a source of profit for the bee-keeper. Their many interesting habits are well worthy of study by careful students.

The bumble bees (Fig. 157) are familiar insects to all country boys. They make small nests usually in the ground, quite frequently in an abandoned mouse nest. The colonies are usually small and are not permanent. At the end of the season all the members of the colony die out save the queens. In the spring, as soon as a queen finds a suitable nesting site she starts a new colony. The first larvæ that she raises all develop into workers. These then aid the queen in raising other workers, and in this way the colony is built up, but at the end of the season all die off except the young queens which live over the winter. Bumble bees are of interest to the farmer because they have long tongues and can reach the nectar in deep flowers like the red clover which cannot be reached by other bees. Thus, the raising of red-clover seed is dependent upon bumble bees.

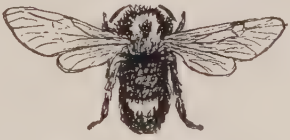


FIG. 157.—Bumble bee.

The social wasps build nests of paper. Those that build exposed nests composed of a single layer of cells are usually called wasps. Those that build large covered nests composed of several layers are usually called hornets, and those that build nests in the ground are usually called yellow jackets. None of these forms make permanent nests, but as in the case of the bumble bees the workers and drones die off in the fall and the queens live over to start new colonies in the spring.

The paper used by the social wasps is made from wood secured by scraping it from the surface of unpainted buildings and fences. This is chewed up by the wasps and mixed with saliva and then moulded into cells or layers for covering the cells. The wasps were

A SUMMARY OF THE CHARACTERS OF THE PRINCIPAL ORDERS OF INSECTS.

Group order.	Examples.	Mouth parts.	Wings.	Legs.	Metamorphosis.
Thysanura	Fish moths	Chewing	Wingless	Running	Without.
Collembola	Springtails	Chewing	Wingless	Walking Locomotion aided by abdominal spring	Without.
Orthoptera	Roaches, walking sticks; mantids, grasshoppers, crickets, katydids	Chewing	Two pairs, first pair leathery, second pair folded like a fan	Running, walking, grasping, leaping	Gradual.
Isoptera	White ants	Chewing	Two pairs with indefinite venation or wanting	Walking	Gradual.
Neuroptera	Ant lions, aphis lions	Chewing	Two pairs membranous with many veins and cross veins	Walking	Complete.
Ephemerida	May flies	Vestigial	Two pairs membranous; first pair longer	Walking	Incomplete.
Odonata	Dragon flies; damsel flies	Chewing	Two pairs membranous. About equal in size	Walking	Incomplete.
Plecoptera	Stone flies	Chewing	Two pairs, membranous; few veins, many cross veins, hind wings larger	Walking	Incomplete.
Corrodentia	Book lice; bark lice	Chewing	Four membranous, few veins and cross veins; or wanting	Running	Gradual.

Trichoptera	Caddis flies	Vestigial in adult, chewing in larva	Two pairs membranous, clothed with hairs	Walking	Complete.
Mecoptera	Scorpion flies	Chewing	Two pairs membranous, many cross veins	Walking	Complete.
Mallophaga	Bird lice, chewing lice	Chewing	Wanting	Grasping	Direct.
Anoplura	Sucking lice; cooties	Piercing	Wanting	Grasping	Direct.
Thysanoptera	Thrips	Scraping	Two pairs fringed with long hairs; few or no veins or cross veins	Walking	Gradual.
Hemiptera	True bugs, stink bugs, bedbugs, chinch bugs	Piercing	Two pairs or wanting; first pair thick at base, overlapping at tip	Walking, running, grasping	Gradual.
Homoptera	Cicadas, leaf, plant, frog and tree hoppers, plant lice, scales	Piercing	Two pairs, sometimes wingless; first pair membranous or leathery	Walking, leaping	Gradual.
Coleoptera	Beetles, snout beetles	Chewing	Two pairs, first pair horny meeting in a straight line down the back	Walking, running	Complete.
Lepidoptera	Butterflies, skippers, moths	Chewing in larva; siphoning in adult	Two pairs covered with scales	Walking	Complete.
Diptera	Mosquitoes, gnats, flies	Piercing, rasping, sponging	One pair membranous; few veins and cross veins	Walking	Complete.
Siphonaptera	Fleas	Piercing	Wanting	Leaping	Complete.
Hymenoptera	Bees, ants, wasps	Lapping	Two pairs membranous; few veins or cross veins	Walking, running	Complete.

therefore, our first paper makers, having been engaged in this process long before man discovered how to make paper.

In addition to the social wasps, there are a number of interesting solitary wasps (Fig. 158). One of the largest of these forms is the cicada killer, which is more than 1 inch long. It digs tunnels in the ground which it provisions with cicadas or July flies. The cicadas are not killed but are paralyzed. They furnish food for the developing larva. Another large wasp is the common horse guard of the South which captures horse flies to provision its nest.

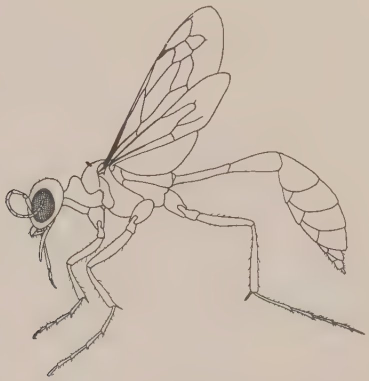


Fig. 158.—Solitary wasps. (Author's illustration.)

The mud daubers are common insects that build their nests of mud which they plaster to rafters and ceilings of buildings. These nests are filled with spiders. Other solitary wasps capture crickets, some grasshoppers and some capture larvæ of various kinds which they store in tunnels. Their methods of digging their tunnels, locating and capturing their prey and relocating their nests have been extensively studied by various students, and accounts of the habits of these insects are among the most interesting in the field of zoölogy.

INSECTS BENEFICIAL TO MAN.

Entomologists lay so much stress upon the damage caused by insects that it is small wonder that the public is inclined to look upon insects as pests and nothing else. It was that eminent British entomologist, Sir John Lubbock, who brought the opposite point of view to our attention forcibly by reminding us that he could make the world a place unfit for human habitation in less than a year's time if he had the power to remove certain insects from the world. Which is simply another way of saying that, while we suffer much from the attacks of injurious insects, we owe much to insects which are our friends and help to keep injurious insects in control.

Entomologists are having these matters forced upon their attention, but apparently the general public misses the significance of the outbreaks of certain species of insects. The army worm is a case in point. Normally this insect is present every year, but not in sufficient numbers to cause any appreciable loss to the farmer. Occasionally, however, the army worm becomes locally or generally abundant and causes widespread destruction and alarm. Even a better illustration is offered by the soy-bean worm. Some years ago this insect threatened the destruction of the soy-bean crop, causing hundreds of thousands of dollar's worth of damage. Yet this insect had never been a serious pest before. Why these sudden outbreaks of insect pests? The reply is that these destructive outbreaks represent what happens when the control exercised by their enemies is for any reason released. In other words it represents the condition that would prevail but for our insect friends.

"The following analysis of a typical outbreak of the army worm will show what usually happens. As is usual during such outbreaks, large numbers of Tachina flies (Fig. 159) were to be found in the fields laying eggs on the worms. With the intention of making a more careful study of these parasites, 491 larvæ were brought back and placed in cages. The following data gleaned from the records of these cages are presented as being of some interest: Of the 491 larvæ, 442 were infested with the eggs of the dipterous parasite, leaving only 49 larvæ, or 10 per cent of the whole number, uninfested; yet 61 larvæ were able to pupate. From these 61 pupæ, however, only 7 adult moths emerged, showing a total mortality among the army worms from larva to adult of 98.6 per cent. Since 90 per cent of the larvæ were infested with the eggs of this parasite, it would seem to indicate that, in this case at least, the parasitic fly was decidedly the most important factor in causing the high mortality of the army worm. In a few cases it was found that where only a single parasitic egg was attached to a larva, that the host was able to complete its transformations.

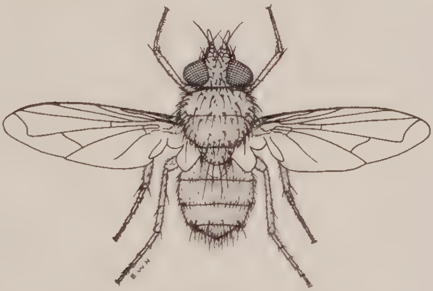


FIG. 159.—Parasitic fly. (Author's illustration.)

"The greatest number of parasitic eggs observed on a single larva was 12, with an average of 3 for the entire number (442) infested. The 442 infested larvæ yielded 709 parasitic puparia, or an average of nearly 2 for each infested larva. The 709 puparia yielded 556 adult parasites. The greatest number of adult flies from a single army worm was 4. These figures show that the mortality of the parasitic fly from egg to puparium was 52 per cent, and from puparium to adult 22 per cent, making a total mortality from egg to adult of 73 per cent.

"This shows that the tendency would be for the fly to continually gain in relative numbers, owing to the lighter mortality, and easily accounts for the complete subjugation of the army worm in normal years by this one natural enemy. No other parasites were found in the course of these experiments."

Since we are so dependent upon these insect friends, perhaps it would not be amiss to inquire a little more closely into their life economy. For convenience we may divide the friends of man into two groups, predacious insects and parasitic insects, but this is merely a matter of convenience and the line separating the two is by no means a sharp one. For example, we might inquire whether the larvæ of the solitary wasps mentioned in another connection were parasitic or predacious, and while in general their behavior is that of a predacious insect there is little doubt that this is simply a further development of a strictly parasitic habit. Likewise, the line separating the predacious insects from the plant-feeding forms is not great. Some species seem to feed predaciously if insect hosts are abundant, but if not available they turn their attention to plants. Hence we feel safe in saying that the evolution of these habits have been from plant-feeding to predacious insects and thence to parasitic insects.

Predacious insects are many and they have varied habits. Some are active and search far and wide for their prey like the ground beetles and tiger beetles. Others are quiescent and construct traps for their prey, like the ant lions. These curious fellows, usually called doodle bugs, construct funnel-like traps in loose, sandy soil and then take up their position at the neck of the funnel and wait for a luckless ant to tumble in. The ant thus starts a miniature land slide which the ant lion aids by throwing loose sand above the ant. Some are predacious only in the larval stage, like the aphis lion or the aphis maggot, while others are predacious both in larval and adult condition, like the lady beetles. The amount of food that these predacious insects will consume is often beyond belief.

"In order to determine something of the capacity of these insects for devouring plant lice, and hence their degree of economic importance, I tried feeding the larvæ of *Syrphus americanus* on cabbage aphids (*Aphis brassicæ* Linn). The aphids were touched to the mouth of a larva which had not been kept from food. A four-day-old larva devoured the first aphid in four and a half minutes; a second, third, fourth and fifth, smaller than the first, in two, one and one and a half minutes, respectively; the sixth, a larger one, was retained for three and a quarter minutes. These were very thoroughly eaten, all the viscera and body fluids being picked and sucked out. After this the lice tendered were not eaten so closely, but killed—a seventh in two minutes, an eighth in one and three-quarter minutes and a ninth in one and a half minutes. An average of less than two minutes for each plant louse, or 240 per eight-hour union day.

"It is, of course, not probable that any larva would ever normally devour aphids so rapidly. Yet when plenty are at hand the number eaten by a larva during its life of eight days to two weeks or more must be very considerable. It should be kept in mind also that it is not the actual individuals eaten, alone, that determine the amount of benefit from these insects, but the fact that in this way the production of enormous number of aphids is prevented. If, as Reaumur has calculated, and others have substantiated, one aphid may be the progenitor of over 5,000,000,000 individuals during her existence of a month or six weeks, we can see at once the important benefit that must arise from the destruction of one or two of these aphids early in the establishment of the colony. It is a fact that the eggs of Syrphidæ are often deposited on the host plant very early or even in anticipation of the arrival of the aphids." (C. L. Metcalf.)

On the other hand, the small amount of food on which these insects seem to be able to survive is almost beyond belief. An observation on the ant lion, a predacious insect, which constructs funnel-shaped traps in the sand for catching ants, will illustrate this point. These funnels averaged more than 4 to the foot in an open space about 150 feet long between a woods and a swamp. The chances of an ant traveling that road were certainly slim, but the chances of an ant lion getting very many full meals must have been correspondingly slim. Yet each one of these little fellows had moved nearly a cubic inch of earth in constructing his funnel.

As important as these predacious insects are, they are by no means as important as the parasitic insects. Allusion has been made to the tachina fly and the army worm. In addition to these parasitic flies, there is a large group of parasitic wasps which are among the most important of the parasitic insects. Many of these forms are so small that very little is known about them. They are, perhaps, the least known of all of the insects. Yet we are gradually accumulating knowledge of these forms and some of the more important points are perhaps worth reporting here. We have among the parasitic wasps many parasites of the egg, larval and pupal stages of insects, but cases of adult parasites are not so common. Sometimes the egg of the parasite is laid in one stage but does not emerge as a perfect insect until a later stage. Usually the parasitic stage is confined to the larva which feeds upon its host while living within the appropriate stage of the host, but sometimes the parasite really lives externally, as is the case with certain parasites of the gloomy scale which we have under investigation. Here the adult parasite lays her egg or eggs under the scale covering the host. The larval parasite attaches itself to the host and sucks it dry, just as a predacious aphis maggot devours a plant louse. When it has completely destroyed the scale it changes to a pupa and thence to an adult. The adult cuts a neat circular hole through the scale covering and makes its escape. One of the most interesting points about this parasite is the apparent ability of the female to tell the scale insects that have been parasitized. Observations on upward of 150 of these parasites have failed to reveal a case where one has made the mistake of ovipositing upon a scale insect that is parasitized. It is exceedingly interesting to watch the business-like way that these little fellows have as they pass from scale to scale, tapping each one with their antennæ until they find a suitable host, then slipping the delicate ovipositor under the scale covering, depositing one or two or three eggs and passing on to the next victim.

Among the many interesting things about these parasites not the least interesting is the small size of many of the forms. This is especially true of some of the egg parasites which are among the smallest known insects. Imagine an insect small enough to pass all of its stages in an insect egg not much larger than the period in ordinary newspaper print and you will have a proper conception of their size. Then when you remember that each adult is furnished with a pair of eyes and a pair of antennæ, three pairs of legs and two pairs of wings, with mouth parts and a digestive system, with a nervous system and sense organs and is endowed with instincts enough to feed on the nectar of flowers and to mate and to lay eggs in the proper host at the proper time and all this in an insect not over 0.25 mm. long, or so small that 100 of them placed end to end just equal 1 inch—with these facts all before you; you will have a proper conception of the marvelous ability of Nature.

The subject of parasitism should not be concluded without mentioning two special phases of insect parasitism, polyembryony and hyperparasitism. Polyembryony is that condition in which one egg gives rise to more than one adult individual. It is known to occur in many groups of the animal kingdom, for example, the identical twins of man and other mammals, the quadruplets of the armadillo and others. But this condition reaches its greatest development among insects where Patterson reports not less than 395 individuals from a single parasitic egg.

Hyperparasitism is even more wonderful than this, for here we have the case of one parasite preying upon another. We have not only the primary parasite which preys upon the host, but a secondary parasite preying upon the primary parasite and a tertiary parasite upon the secondary parasite and apparently in rare cases a quarternary parasite preying upon the tertiary. Can anything more involved be imagined? Can man ever hope to unravel the intricacies of the relations that must exist in such elaborate cases of hyperparasitism?

INSECTS FURNISHING PRODUCTS USEFUL TO MAN.

Honey Bees.—Insects produce or gather a number of products that are useful to man. One of the most important insects of this kind is the honey bee. The honey bee collects the nectar from flowers and carries it to the hive in its honey sac. The sugar saccharose in the nectar is converted into invert sugars, and the dilute watery nectar is evaporated down to form the thick syrup-like honey. It is estimated that it requires about 20,000 trips by a bee to collect enough nectar to make a pound of honey. It is estimated further that 250,000 tons of honey are collected and stored in the United States each year.

Honey bees produce beeswax, which is used extensively by man. It is estimated that we use each year in the United States about 10,000,000 pounds of beeswax. Beeswax is secreted in special wax glands located on the underside of the abdomen of the worker bees. Bees that are secreting wax eat large amounts of honey. This food is converted by the wax glands into wax at an average rate of about 10 pounds of honey for 1 pound of wax.

A great deal of wax is used in making foundation which is a thin sheet of beeswax stamped with six-sided figures like the bottoms of the cells of honey-comb. Some is used in cosmetics, like lip-sticks. Some is used in taking casts of objects that have fine details. In fact, there are a great many different ways in which the wax is used.

Silkworms.—Silkworms are the larvæ of the silkworm moth. They are extensively raised in the Orient and Southern Europe for this purpose. Silkworms are fed on the leaves of mulberry trees. In about a month they are full grown and then they spin fine silken cocoons in which they pupate. It is the fine silken thread which forms the outer cover of the cocoon that makes the silk of commerce. In the production of silk the pupæ are killed and the silken thread is reeled off. Each cocoon furnishes about 1000 feet of thread. The silk thread as it is reeled from the cocoon is washed and cleaned in a number of ways before it is ready to spin. This thread, however, is too delicate for weaving. The thread of commerce is made by spinning several strands of silk together. This thread can be used for weaving. It requires about 25,000 cocoons to make 1 pound of silk, and the world requires more than 50,000,000 pounds of silk each year, with a value of $500,000,000.

Lac Insect.—The lac insect is one of the scale insects of Asia. It secretes a wax known as shellac, which protects its body. Shellac is the base used in making varnishes and lacquers of various kinds. It also has many other uses in modern industry. Shellac collected from trees where the lac insect lives is refined by various mechanical and chemical methods, and is sent to the market in thin flakes, which are dissolved in various solvents, such as alcohol, to make varnishes. It is estimated that the United States uses about $15,000,000 worth of lac each year.

Chinese wax is a white wax secreted by plant hoppers. It is used by the Chinese to make candles and for other purposes in the arts. It has been largely replaced by paraffin secured in refining petroleum.

Cochineal.—Cochineal is a beautiful red dye made from the dried bodies of a scale insect that lives on cactus. This insect lived originally in Mexico, but is cultivated in other parts of the world. It was formerly more important than at the present because it has been largely replaced by the cheaper aniline dyes.

INSECTS AND DISEASES.

The discovery of the relation between insects and diseases of man and his domestic animals is one of the brightest pages in the history of medicine. About thirty years ago it was discovered that the cattle tick, which is not an insect, transmitted Texas fever from cow to cow. This was the beginning of a series of brilliant discoveries which demonstrated the relation between malarial mosquitoes and malarial fever; house flies and typhoid and summer diarrhea; yellow fever mosquitoes and yellow fever; tse-tse flies and sleeping sickness; mosquitoes and elephantiasis; lice and typhus fever; fleas and bubonic plague; and a number of other diseases of minor importance. These discoveries have led to widespread improvements in sanitation, especially in the tropics. What were formerly cities and towns reeking with disease have been transformed into sanitary cities. Whole areas of the globe have been rendered fit for human habitation, although much remains to be done in the control of these insect-borne diseases. The building of the Panama Canal was delayed for years until our knowledge of insect-borne diseases made it possible to make this area sanitary enough for the workman to live. The following tables will help in an understanding of the relations between these diseases and the insects which carry them.

Flies -Typhoid and Other Intestinal Diseases.—House flies (Fig. 155) have long been familiar and troublesome pests about the house, but it is only within the last few years that we have realized

Some Common Diseases Carried by Insects.

(Modified from Metcalf and Flint.)

Disease.	Insect carrier.	Method of transmission.	Disease germ.	Animal affected.	Other ways of getting disease.	Distribution of disease.
Typhoid and summer diarrhea	House fly	On the feet of the fly	Bacterium	Man	From contaminated food or drink	Cosmopolitan.
Malaria	Malarial mosquito	Injected into the blood with saliva	Sporozoan	Man	None	Warmer parts of globe.
Yellow fever	Yellow fever, mosquito	Injected into the blood with saliva	Spirochete	Man	None	Tropical and subtropical parts of America and Africa
Sleeping sickness	Tse-tse fly	Injected into the blood with saliva	Trypanosoma	Man	None	Tropical Africa.
Nagana	Tse-tse fly	Injected into the blood with saliva	Trypanosoma	Domestic animals	None	Tropical Africa.
Bubonic plague	Fleas	Injected into the blood with saliva	Bacterium	Man, rat, ground squirrel	Breath of plague victim	Cosmopolitan.
Elephantiasis	Mosquitoes	Injected into the blood with saliva	The roundworm, filaria	Man	None	Warmer parts of the globe.
Typhus fever	Lice or cooties	Deposited in feces of louse and scratched into skin	Bacterium	Man	None	Europe.
Dengue	Mosquitoes	Injected into the blood with saliva	Unknown	Man	None	Tropical and subtropical parts of the world.

the relation between these pests and certain diseases, such as typhoid and summer complaint of children. In fact, this relation is so close that it has been suggested we should call this fly the "typhoid fly" instead of the house fly.

This insect is so familiar that it hardly needs description. There are one or two points to which our attention should be directed. In the first place this fly cannot bite or pierce the skin. Its mouth parts are soft and fitted for lapping up liquids, or for reducing such substances as sugar, which can be easily dissolved, and then lapping up the liquid. The fly that looks like a house fly and can bite is the stable fly.

In the second place we should notice that the fly is covered with hair, especially its feet. The life of the adult fly is a short but busy one. They are busy laying eggs and in visiting dining rooms and kitchens for food. When we remember what a short journey it is, on the average farm, from the stable, privy and pig pen to the kitchen and dining room, and then remember how hairy the body of the fly is, we can see at once what an excellent carrier of filth the fly is. Along with this we must remember that people suffering from typhoid, for instance, discharge typhoid germs a long time before they show symptoms of the disease, and that in some cases they continue to discharge germs for a long time, even years, after they are apparently well. Then stop to think how dirty flies are, how they go to the filthiest of places to lay their eggs and then come directly to the kitchen or dining room to crawl over our food, or, as has been suggested, to wipe their feet on our food. We see at once not only how very unclean the fly is, but how dangerous. Typhoid may be carried by other means than by the fly, so that perhaps we will never know exactly how important the fly is in this respect.

In addition to carrying typhoid, the fly also carries the germs of the disease called summer complaint of children. That the relation between these two is very important may be shown in a number of ways, but perhaps the most important clew is found in the close relation between the number of flies and the number of cases of summer complaint.

Mothers have long known that the summer time is hard on babies, and this has been blamed on various things; however, let us lay the blame where it belongs chiefly and give the fly full credit. From slop barrel, unsanitary privy or what not, to baby's food is an all too short journey. When we remember that one good, strong, able-bodied fly is able to carry millions of germs on his feet we can readily see how dangerous he is and we will cease to wonder why it is that so many babies are sick in the summer time (fly time).

The Life History of the Fly.—In the light of these facts, the life history of the fly becomes very important, because it is only by studying its life history that we can fight this pest with any assurance. Flies lay their eggs in all sorts of filth, but principally in stable manure. In a few hours small white maggots hatch from these eggs and feed on the manure, growing so rapidly that they are full grown in a few days. The length of time that flies spend in this stage is very important for any proper system of control of the house fly. This time will vary from as few as three days in the summer to at least two weeks in the spring or fall. After the larvæ have become full grown, they change into little brown capsule-shaped pupæ, inside of which the fly is formed and from which it later emerges. This stage is also about as long as the larva stage, so that we can have a new brood of flies every two weeks. When we recall that every female fly may lay about six hundred eggs, we cease to wonder why there are so many flies by the end of the summer and begin to wonder why there are no more.

Mosquitoes and Malaria.—Mosquitoes have long been known as troublesome pests of man, as they frequently occur in large numbers and their bites are painful. This phase of the subject is dealt with in connection with household insects. (See page 265.) However, there is another phase of the problem that is really more important than this annoyance, and that is the diseases carried by mosquitoes. Throughout the country generally, and especially in the South, one of the most troublesome diseases on the farm is malarial fever, chills and fever or ague, as it is often called. It is only in comparatively recent years that we have known the real cause of this disease. Formerly it was supposed that one could acquire the disease by breathing night air, by being in a swamp or any one of a half hundred other different ways; however, recently it has been shown that this is the work of one kind of troublesome mosquitoes, *Anopheles*. Only these mosquitoes can carry malaria and they can be recognized very easily by the fact that they have black and white spotted wings, and by the fact that when they bite they seem to stand on their heads. The life history of these mosquitoes is very nearly like that of the common mosquitoes in that they breed in water.

There are some important differences which it is not necessary for us to point out here. Suffice it to say, that almost any stagnant water may become a breeding place for these or the common mosquitoes.

So far as is known, malaria can only be transmitted from one person to another by the bite of these spotted winged or malarial mosquitoes (Fig. 160). Such a mosquito must first bite a person that has malaria and then in a few days if it bites a person free from malaria, the second person is very apt to acquire the disease. Obviously, from these facts it is necessary to have a chain of events before anyone can acquire malaria. (1) We must have a person suffering from malaria; (2) malaria fever mosquitoes; (3) these mosquitoes after biting the patient must bite a person not having the disease.

It is clear then that our line of attack on this disease is to break this chain. There are three places that the chain may be broken: (1) Either we can prevent the mosquitoes from biting malarial patients, or (2) we can kill the mosquitoes, or (3) we can prevent persons not suffering from the disease from being bitten.

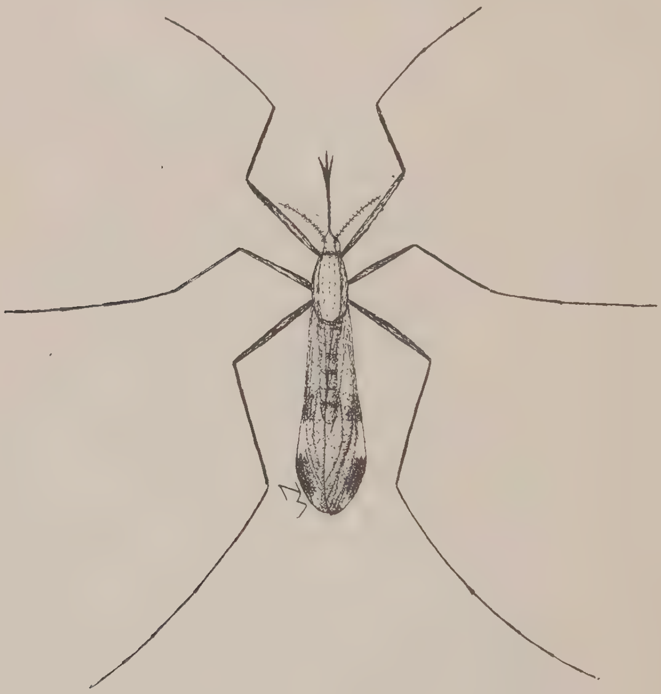


Fig. 160.—Malarial mosquito. (Author's illustration.)

Under the first of these heads we may treat the patients with some medicine, such as quinine, which will kill the germs of the disease, or we may screen the patients so that they are not liable to be bitten by mosquitoes. The first of these methods is most effective if applied during the winter and should always be carried on under the direction of a competent physician. We believe now that the malarial germ lives over winter only in the bodies of persons who have suffered from the disease. If this is the case, very great good can be accomplished in checking this disease by the proper treatment in the winter time.

The second of the remedies should always be followed during the summer time when the mosquitoes are active. Patients who suffer from malaria should not stay out after dusk, but should retire to screened houses, porches or rooms where they should remain until the following morning. These rooms or porches should be gone over every day to see that no mosquitoes have gained entrance. If any such are found they should be destroyed.

Under the second of these heads is the drainage of our swamp lands. As more and more of our swamp lands are drained, this pest will become less and less important. Along with this it must be remembered that these pests can breed in stagnant water anywhere, so that all such places should be removed or rendered unfit for breeding places. Streams should be made as straight as possible and should be graded so that they can flow as swiftly as possible. The doing away with all of the side pools of a stream will reduce the number of mosquitoes very greatly. Lakes and ponds should have their banks made steep, so that there will be no shallow, marshy places for the mosquitoes to breed. It would be better if the banks of all ponds could be lined with stones, so that there would be no chance for water weeds to grow up along the edges, as this would greatly reduce the chances of mosquitoes breeding and would increase the chances that the wigglers would be eaten by fish.

Persons who are not suffering from malaria should take every precaution not to be bitten by mosquitoes. Their houses should be well screened or they should sleep under a mosquito net. In addition, they should become familiar with the appearance of the malarial mosquito and should kill it at every possible chance. People who live in a malarial district or who expect to travel in such a district should protect themselves by taking quinine.

INSECTS AS FARM PESTS.

Loss from Insect Pests.—Hordes of pests threaten our crops each year and levy a heavy tax on what they do not destroy. Others invade our homes, destroying our food or making life miserable by their poisonous bites or stings. Others carry from place to place man's most dread diseases or annoy his domestic animals. Careful estimates made several years ago indicated that this damage would reach the startling total of $1,250,000,000 annually. What it is today when farm crops have doubled or even trebled in value, one would hardly dare say. There is, however, another way that the figures become even more startling. Anyone, who has observed farm crops at all carefully, is forced to conclude that in general from one-tenth to one-half of the value of the crop is paid each year as a tax to the various kinds of pests which prey upon it. Some crops, it is true, will almost completely escape, whereas other crops will be entirely destroyed. Farmers have become so used to paying this tax that anything less than complete destruction hardly causes them any concern. Yet a similar heavy tax placed by a local, state or national government for necessary expenses for the public good would be followed by a serious protest, but because we have always paid this tax to pests seems to be ample reason in the minds of most of us why we should continue to pay it. It is a pleasure to note, however, that gradually it is dawning upon us that this is an unjust tax and gradually we are learning that such a tax can be reduced. Here, as in many other phases of life, an ounce of prevention is worth a pound of cure; so in the following pages we stress the desirability of meeting these, our foes, more than half way and giving battle on their own ground.

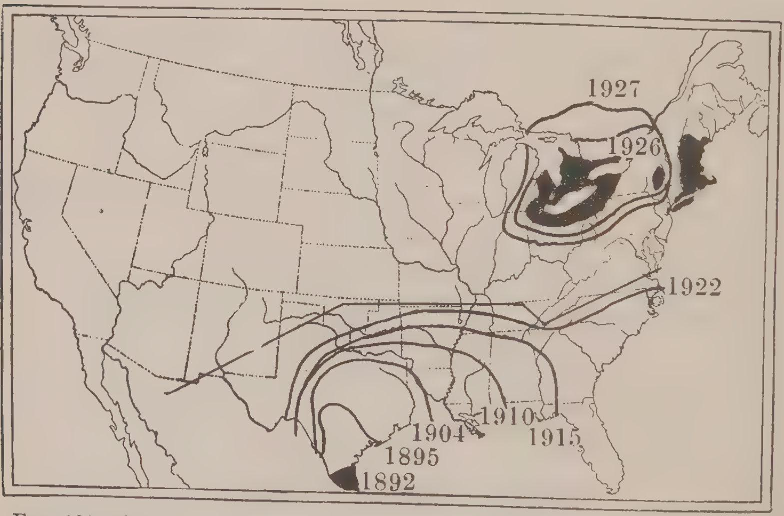


Fig. 161.—Map showing spread of cotton boll-weevil in the Southern States. Original infestation in black. Spread of European corn-borer in Northern States. Area infested up to 1926 in black.

Foreign Pests.—Many of our worst pests at the present time have come to us from other lands and have found here conditions of climate, or of soil or crops to their liking, and have spread, or are spreading gradually until they have occupied, or will occupy, we believe, all the available territory. Such invasions in the past have been made by the cabbage worm and San Jose scale. Such invasions are being made, at the present time, by the gypsy and brown-tail moths and corn-borer on the Northeast (Fig. 161) by the cotton boll-weevil, pink boll-worm and Mexican bean beetle (Fig. 162) on the South; by the Japanese beetle and Oriental fruit moth on the East; more recently by the Mediterranean fruit fly in Florida.

These invaders are more to be feared than foreign warships and foreign human armies. For, once established, these armies of pests will remain and will continue to levy a heavy tax for many years.

Native Pests.—Not all our pests, however, are of foreign origin. Many of them are native forms which lived formerly on wild plants nearly related to cultivated forms, but which found that the large planting of cultivated plants offered a much more constant supply of food and a better chance of reproducing their kind. Perhaps the best-known case of this kind is that of the potato bug or beetle. It formerly lived in the Rocky Mountain region on a weed belonging to the potato family, but readily transferred its attention to cultivated potatoes and quickly spread to all parts of the country from its original home in the Rocky Mountains. Thus we are constantly threatened from within and from without by new enemies which may attack us at any time. We can discuss in only the most generalized way some of the more important insect pests of the United States.

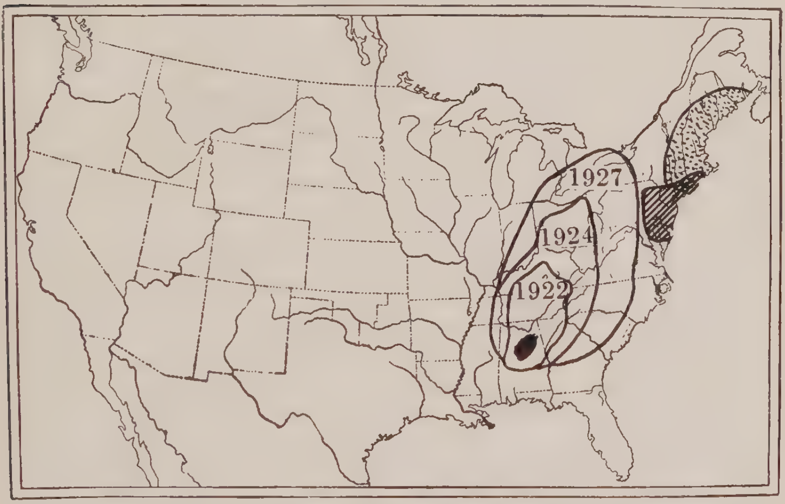


Fig. 162.—Map showing distribution of Mexican bean beetle in eastern North America, in outline. Original infestation, 1920, solid black. Area with diagonal lines, distribution of Japanese beetle. Dotted area, distribution of gypsy and browntail moths.

All cultivated crops are attacked by insects and all parts of the various plants are ravaged by them. Roots, stem or trunk and branches, buds, leaves, flowers and fruit are all attacked. Some kinds of crops are more severely damaged than others. Thus the apple has no less than 7 pests that are generally distributed and do serious injury every year unless careful measures are taken to prevent their attacks. There are about 15 that are not so generally distributed or that do not usually damage the crop every year. In addition, some 20 odd that are occasionally troublesome or do minor injury every year. To this list of more than 40 insect enemies of the apple could be added many more that feed on the apple, but do no considerable injury. A survey of corn insects shows about 9 of major importance, 8 of ordinary importance and 6 of minor importance. On tobacco 4 of major importance, 3 of ordinary importance and about 12 of minor importance. On the peach 5 of major importance, 5 of ordinary importance, 3 of minor importance and a host of others. Some crops, on the other hand, are not attacked by so many insects nor nearly so seriously. The peanut does not have a single insect pest of major importance, but does have 3 or 4 of ordinary importance and several of minor importance. The same is generally true of rye, oats, timothy, soy beans, cowpeas, sweet potatoes and the quince.

Sucking Insects of Importance.—Insects do their damage to crop plants in one or two ways, either by sucking the sap from root, stem or leaf or by chewing and devouring the plant substance of the various parts of the plant. The sucking insects may be divided for convenience into the following groups: The plant lice, or aphids, the scale insects, the stink bugs and the plant hoppers. The chewing insects may be divided into the following groups: The seed destroyers, root worms, borers, leaf eaters, bud worms and fruit and seed eaters.

The plant lice or aphids suck the sap from root, stem, branch or leaf. In addition to the injury caused by the loss of sap the parts of the plant are frequently much distorted by abnormal growth caused by the activities of these insects. Thus, the woolly aphid of the apple produces knots on the roots of the tree attacked, several times the size of the diameter of the root. Many of the aphids attacking leaves cause the leaf to curl and others produce an irregular growth which forms open pockets, in still other cases, as in the phylloxera, distinct galls, often of elaborate design, are formed.

The principal root aphids are the corn and cotton-root aphid, the grape phylloxera and the woolly aphid of the apple. In the wooly aphid (Fig. 163) there are both aërial and root forms, but it is the root form that does the most damage. The aërial forms live not only on the apple and the closely related mountain ash and hawthorn, but also on the elm, where the females lay eggs that live over the winter. The forms that hatch from these overwintering eggs migrate back to the apple in the spring.

In the corn and cotton-root aphids there are no aërial forms and the aphids are not able to migrate from plant to plant. Eggs are laid in the fall and these eggs are cared for over winter by the cornfield ants which take the eggs to their nests where they are kept under proper conditions of temperature and moisture. In the spring when the eggs hatch the young nymphs are carried by the ants to the roots of weeds if corn or cotton is not available and then later transferred to the roots of the cultivated plants. The ants care for the aphids during the summer, transfering them from plant to plant if necessary. In return for this care which the ants give the aphids the aphids excrete a large amount of honey dew which the ants devour.

Many of our cultivated plants are injured by leaf aphids; the list even of the principal forms would be a long one and would include the apple aphids, the cabbage aphid, the pea aphid, the melon—cotton-leaf aphid, the green bug of wheat and the rose aphid. All these forms cause the leaves to curl and become misshapen, stunt the growth of the plant and if abundant may cause the death of the plant.

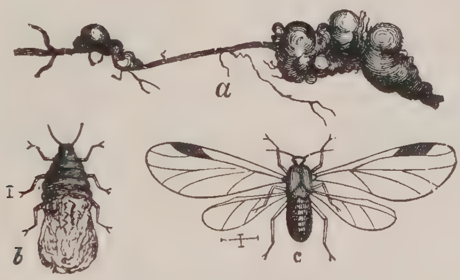


Fig. 163.—Woolly aphis. *a*, root showing nodules; *b*, wingless form; *c*, winged form. (U. S. Dept. of Agriculture.)

The scale insects (Fig. 164) are another large group of very injurious insects. They suck the sap from the twigs and branches principally. Although the scale insects are small insects, averaging about the size of a pin-head, they occur in such numbers that if left unchecked they kill the plant. Some species, such as the San José scale, attack a long list of plants, being destructive to many members of the rose family, especially the fruit trees, such as apple, peach, plum and cherry. Other scale insects are apparently confined to a single species of plant or to the members of a single genus as the euonymous scale. In other cases, such as the gloomy scale of the maple, the insect confines its attacks principally to the group of maples called soft maples.

The term stink bug as used here includes all the members of the *Order Heteroptera* or true bugs. Most of these insects produce a powerful odor, hence the name stink bug. The most important pests of this group include the chinch bug (Fig. 165), which is so destructive to corn and small grains, the harlequin bug (Fig. 166), which is one of the chief pests of cabbage and related plants, and the squash bug, which feeds on squashes, melons and related crops.

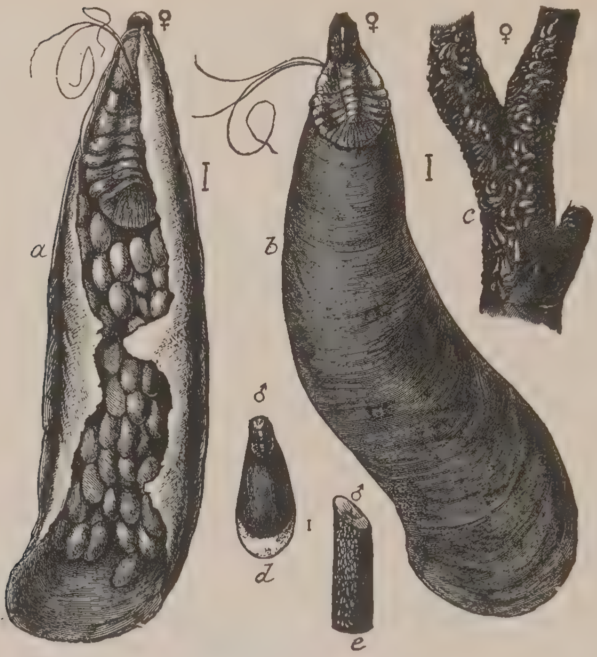


FIG. 164.—Oyster-shell scale. *a*, female laying eggs; *b*, female scale; *c*, twig covered with females; *d*, male scale; *e*, twig covered with male scales. (U. S. Dept. of Agriculture.)

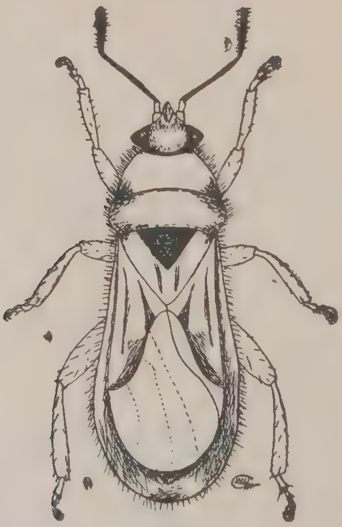


FIG. 165.—Chinch bug. (Author's illustration.)

In some cases the insects occur in such hordes that the damage is not surprising. Thus the chinch bug sometimes swarms on corn to such an extent as to almost completely cover the stalk. In other cases the damage that a few bugs can do seems out of all proportion. Thus, a few squash bugs may kill a small plant or seriously injure a large plant.

The plant hoppers, including the *Families Membracidæ, Cicadellidæ* and *Fulgoridæ,* are mostly small or very small insects. Some of the forms do considerable damage because they literally swarm over the plants and suck an enormous amount of sap from the plants attacked, while others transmit the virus of serious plant diseases. These insects swarm in meadows and pastures and do a not inconsiderable damage in such situations. Other plant hoppers of importance include the apple-leaf hopper; the bean-leaf hopper, which is a pest of first importance of the apple, bean, potato, soybean and peanut, causing the disease called tip burn; the beet-leaf hopper, causing curly top of sugar beets; and the grape-leaf hopper, which is an important enemy of grapes.

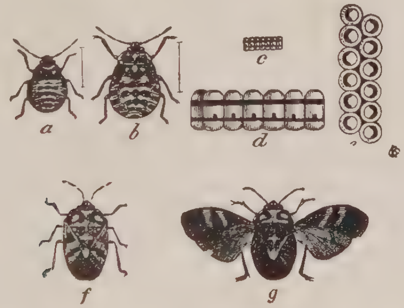


FIG. 166.—Harlequin bug. *a* and *b*, nymphs; *c*, *d* and *e*, eggs; *f* and *g*, adults.

Chewing Insects of Importance.—Only a few of the outstanding chewing insects can be discussed here and even these only very briefly, as the list of important chewing insects which attack crop plants in America is a very long one.

A few insects attack sprouting seeds and destroy them before the plant has a chance to start to develop. This group includes the wireworms and the seed-corn maggot. Wireworms (Fig. 167) are the larval stages of the click beetles, *Family Elateridæ*. They are especially destructive to corn. The seed-corn maggot is the maggot stage of a small fly which attacks not only corn but many garden vegetables, destroying the sprouting seeds or injuring the small seedlings.

There are a number of subterranean insect larvæ which destroy the roots of plants or tunnel the underground stems. This list includes the white grubs, *Family Scarabæidæ* (Fig. 168), which are often very injurious to corn planted in land that has been in sod the previous year, the corn-root worms which tunnel the stem below ground and often completely destroy the crop, as well as a number of lesser importance, including the cabbage maggot, the clover-root borers and others.

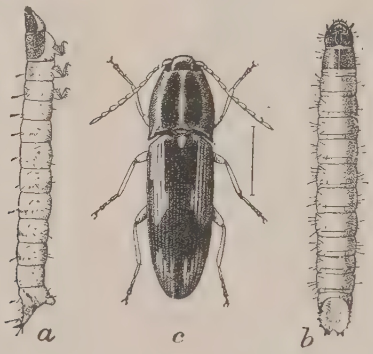


Fig. 167.—Wireworm. (U. S. Dept. of Agriculture.)

The borers include the larvæ of Lepidopterous and Coleopterous insects which bore into the stems of herbaceous plants and into the trunk and larger branches of trees. They devour not only considerable plant substance, but they often so weaken the stem or trunk that the plant is broken off by the wind. The corn plant is injured by a number of borers, including the recently introduced European corn-borer, the larger corn-stalk borer and billbugs. The Hessian fly maggots (Fig. 169) do a similar injury to wheat, although they do not actually bore into the stem. The trunk of the apple tree is often completely riddled by the round and flat-headed apple-tree borers. While one of the most serious pests of the peach is the

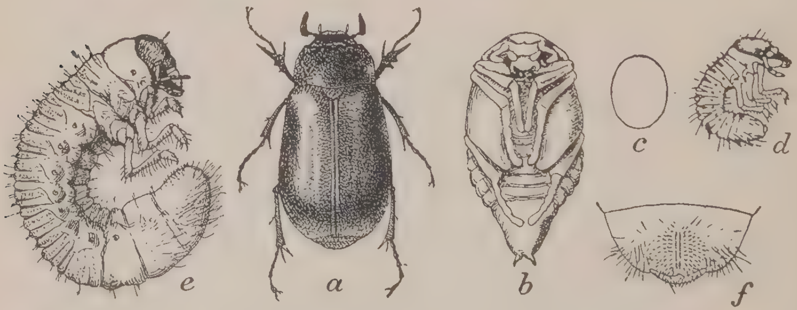


Fig. 168.—Grub worms. (U. S. Dept. of Agriculture.)

peach-tree borer, which often completely girdles the tree at the surface of the ground. The bark beetles or shot-hole borers, *Family Scolytidæ*, include a large number of small beetles whose larvæ live in the sap wood of various fruit, shade and forest trees, often completely girdling the trees and causing their death.

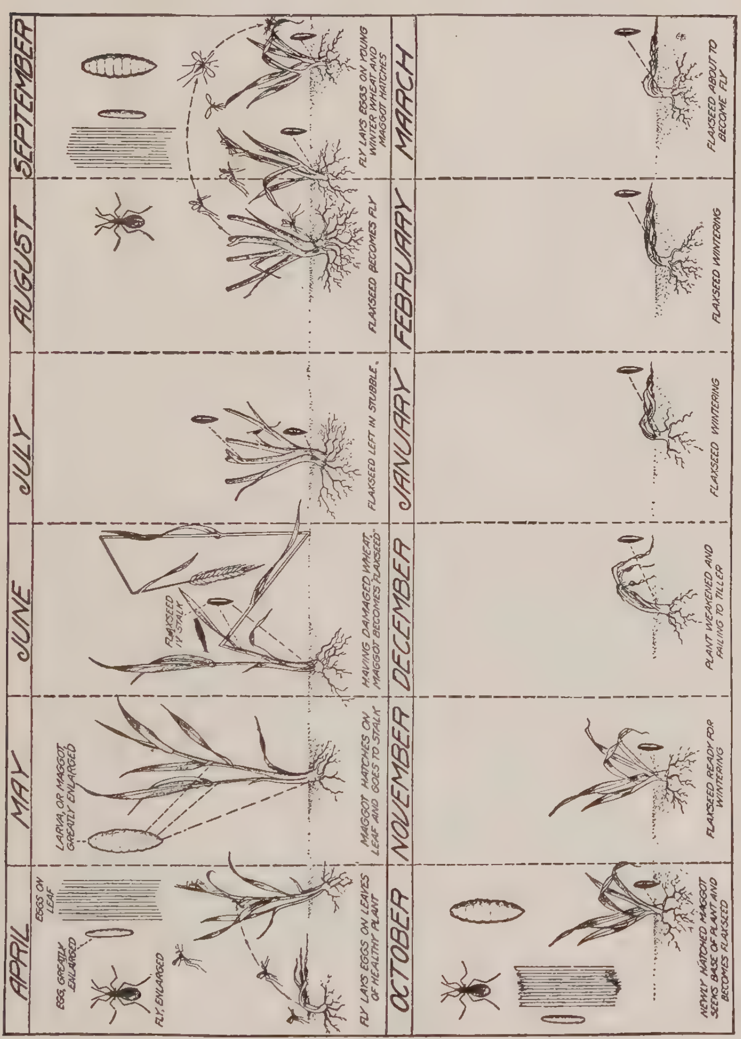

APRIL
EGG, GREATLY ENLARGED
EGGS ON LEAF
FLY, ENLARGED
FLY LAYS EGGS ON LEAVES OF HEALTHY PLANT
MAY
LARVA, OR MAGGOT GREATLY ENLARGED
MAGGOT HATCHES ON LEAF AND GOES TO STALK
JUNE
FLAXSEED IN STALK
HAVING DAMAGED WHEAT MAGGOT BECOMES "FLAXSEED"
JULY
FLAXSEED LEFT IN STUBBLE.
AUGUST
FLAXSEED BECOMES FLY
SEPTEMBER
FLY LAYS EGGS ON YOUNG WINTER WHEAT AND MAGGOT HATCHES
OCTOBER
NEWLY HATCHED MAGGOT SEEKS BASE OF PLANT AND BECOMES FLAXSEED
NOVEMBER
FLAXSEED READY FOR WINTERING
DECEMBER
PLANT WEAKENED AND FAILING TO TILLER
JANUARY
FLAXSEED WINTERING
FEBRUARY
FLAXSEED WINTERING
MARCH
FLAXSEED ABOUT TO BECOME FLY

FIG. 169.—Diagram showing seasonal development of the Hessian fly. (From Lochhead's "Class Book of Economic Entomology;" courtesy of P. Blakiston's Son & Co., Inc.)

The leaves compose the bulk of many plants and they furnish food for many kinds of insects. There are more leaf-eating insects of importance than of any other group. Grasshoppers are import-

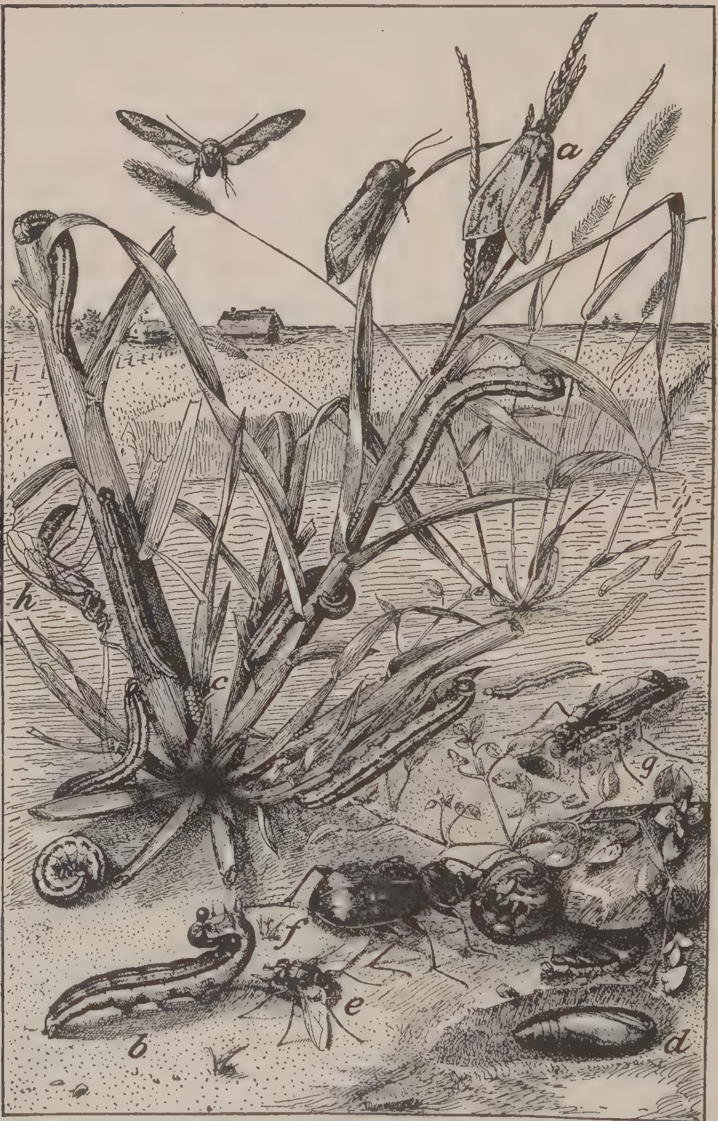


FIG. 170.—Stages and work of the true army worm (*Cirphis unipuncta*) and some of its insect enemies: *a*, parent or moth; *b*, full-grown larva; *c*, eggs; *d*, pupa in soil; *e*, parasitic fly (*Winthemia quadripustulata*), laying its eggs on an army worm; *f*, a ground beetle (*Calosoma calidum*),preying upon an army worm, and at right *Calosoma* larva emerging from burrow; *g*, a digger wasp (*Sphex spp.*), carrying an army worm to its burrow; *h*, *Enicospilus purgatus*, a wasp-like parasite of the army worm, natural size. (U. S. Brureau of Entomology.)

ant leaf-eating insects, being especially destructive to grasses and related crops like corn. Sometimes grasshoppers, often called locusts, fly across great stretches of country devouring the crops as they go. The Middlewestern States suffered several invasions of the Rocky Mountain locust in this way. Many of the leaf eaters are the caterpillars of moths and butterflies. The destructive army worms (Fig. 170), which often march like an army across fields of corn and grass-like plants devouring everything as they go; the horn worms of tobacco, the cabbage worms, the web worms and tent caterpillars and the recently introduced gypsy and brown-tailed moths belong here. The Coleoptera also furnish a number of important leaf eaters. There are a number of leaf beetles of importance, one of the best known is the Colorado potato beetle (Fig. 171), which often completely destroys whole fields of unsprayed potatoes. The flea beetles are small leaf beetles which eat small holes in the leaves of various plants. Two of the most important flea beetles are the tobacco flea beetle (Fig. 172) and the potato flea beetle. The lady beetles furnish two leaf eaters of importance, the Mexican bean beetle which has been recently introduced into the eastern United States and the squash lady beetle. There are also a number of weevils whose larvæ feed on the leaves of plants, perhaps one of the most important being the alfalfa weevil which is so destructive to alfalfa in the Western States.

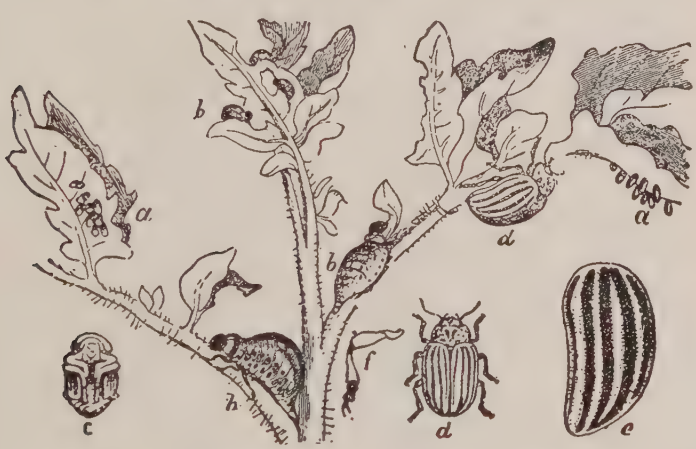


Fig. 171.—Potato beetle. (U. S. Dept. of Agriculture.)

The buds of developing leaves and flowers are attacked by a number of caterpillars, beetles and weevils. The tobacco-bud worms and the corn-ear worm often completely riddle the unfolding leaves of tobacco and corn. Two closely related weevils, the notorious cotton boll-weevil (Figs. 173 and 174), and the strawberry

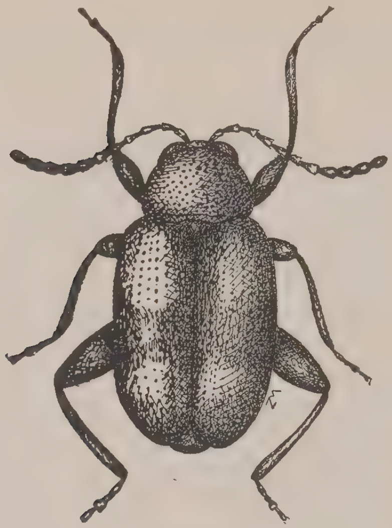


FIG. 172.—Tobacco flea beetle. (Author's illustration.)

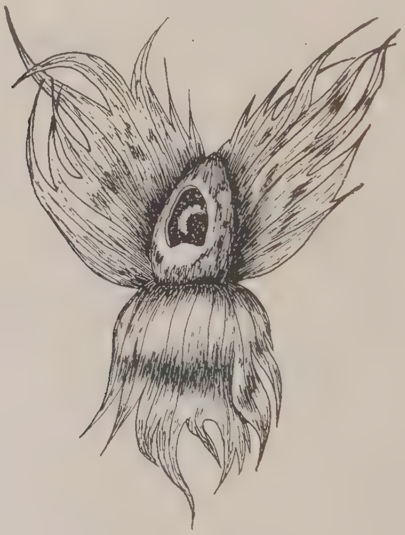


FIG. 173.—Boll-weevil larva. (Author's illustration.)

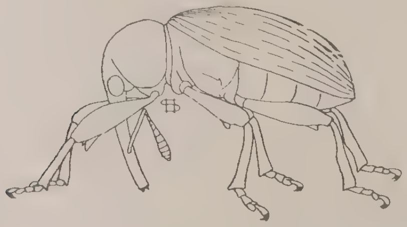


FIG. 174.—Adult cotton boll-weevil. (Author's illustration.)

weevil damage the respective crops by killing the flower buds, which drop to the ground.

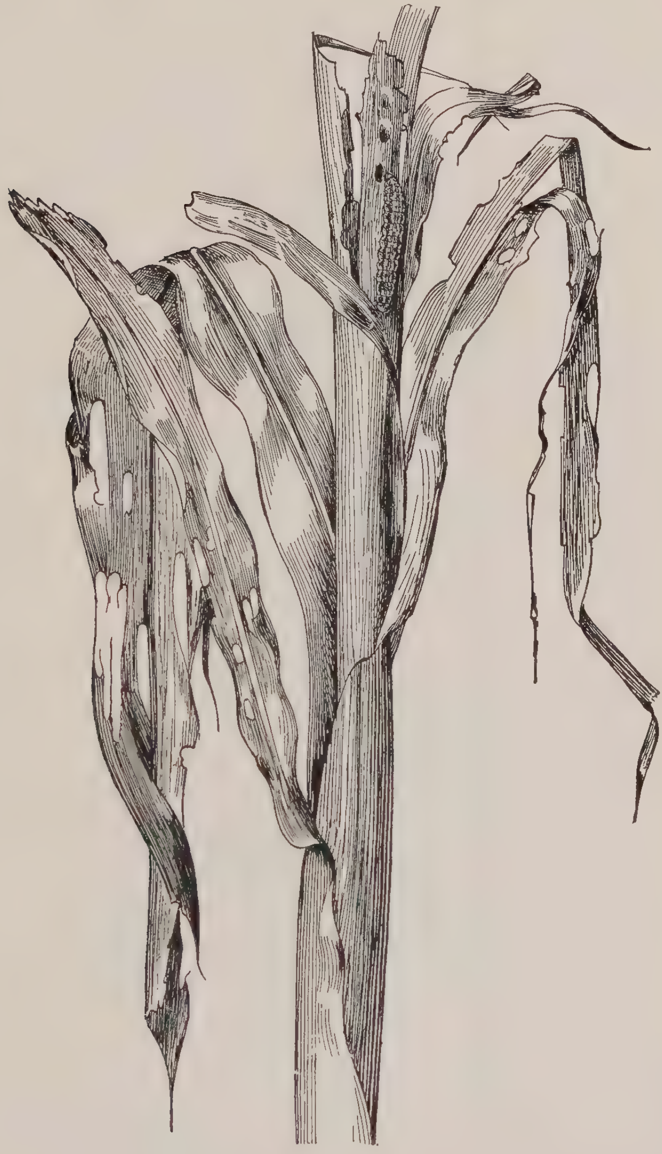


Fig. 175.—Corn injured by corn-ear worm. (Author's illustration.)

Vegetable fruits and tree fruits suffer from the attacks of many kinds of insects. These insects are chiefly lepidopterous caterpillars and coleopterous grubs. The corn-ear worm (Figs. 175 and 176) and the European corn-borer bore into the ears of corn destroying the grain. The melon worms bore into cucurbit fruits, such as melons, squashes and cucumbers, making them unfit for food. The cotton boll-weevil and the pink boll-worm lay eggs in the bolls of cotton. These eggs hatch into grubs and caterpillars, which destroy the developing cotton. The larvæ of the codling moth (Fig. 177) and the apple maggot tunnel through the apple, while the larvæ of the curculio (Fig. 178) and the Oriental fruit moth tunnel the peach, making them unfit for food.

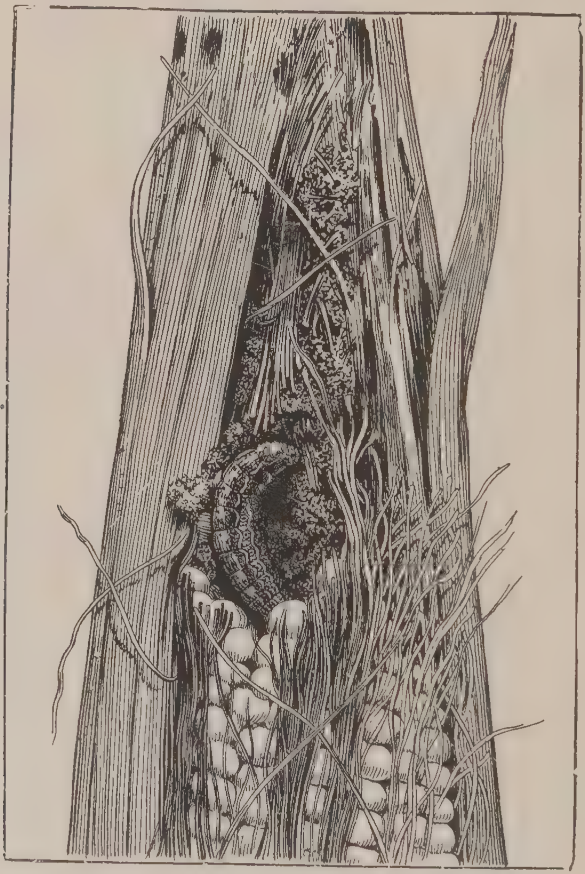


Fig. 176.—Corn-ear worm. (U. S. Dept. of Agriculture.)

Insect Pests of Stored Grain.—Grain of all kinds in storage is attacked by a large number of pests of two general classes. There are first the various kinds of beetles, usually known as weevils

(Fig. 179), and second the various kinds of moths or "millers," sometimes called "fly weevils" (Fig. 180). There may be a great

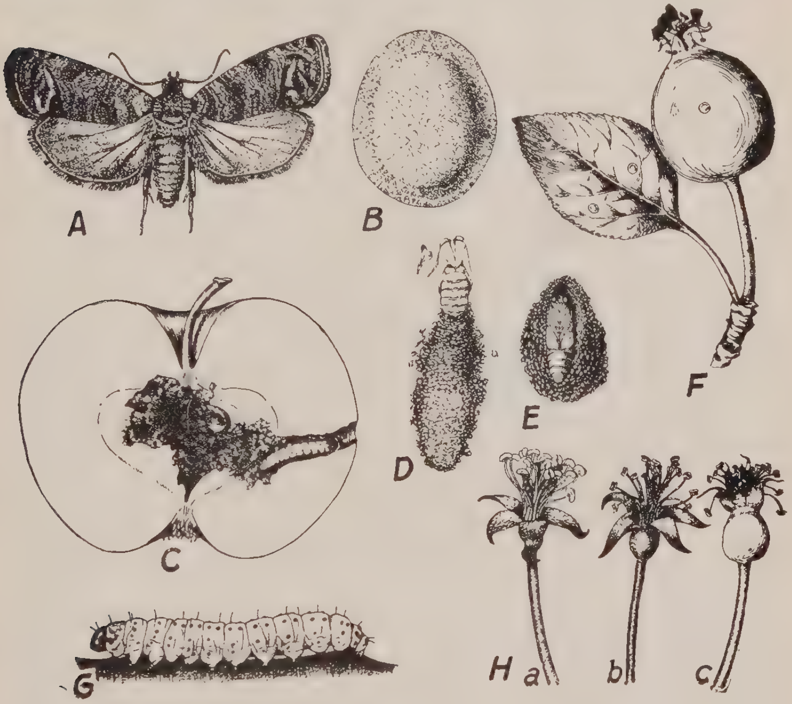


FIG. 177.—Codling moth. *A*, adult moth with wings expanded; *B*, egg much enlarged; *C*, half of worm-eaten apple; *D*, cocoon with empty pupa shell protruding; *E*, cocoon with pupa enclosed; *F*, leaf and apple showing eggs of a codling moth; *G*, caterpillar or "apple worm" enlarged; *H*, a, young apple just after petals fall; b, cup beginning to close; c, too late to spray. (Montana Agricultural Experiment Station.)

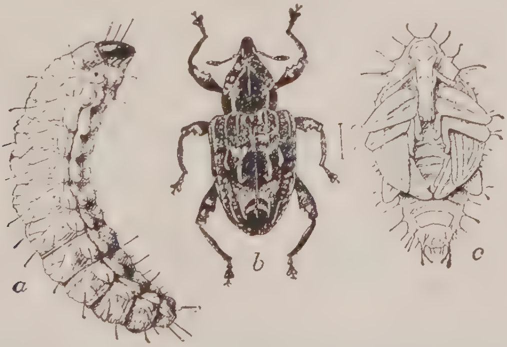


FIG. 178.—Peach curculio. *a*, larva; *b*, adult; *c*, pupa. (From Lochhead's "Class Book of Economic Entomology;" courtesy of P. Blakiston's Son & Co., Inc.)

number of different kinds of weevils present in a bin at the same time. Both classes of insects do damage in the same way, eating out the kernels of the grain. If left undisturbed they will frequently ruin the grain in a single year. Along with the destruction of the kernels of the grain goes the heating of the grain. If the grain is damp when it is stored, the heating is much more evident and weevils of all kinds develop much more rapidly than if the grain is thoroughly dry before it is thrashed and stored. Since all of these insects are about

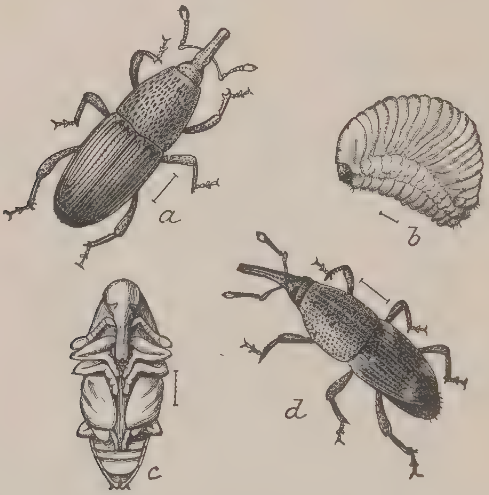


Fig. 179.—Grain weevil. *a* and *d*, adults; *b*, grub; *c*, pupa. (U. S. Dept. of Agriculture.)

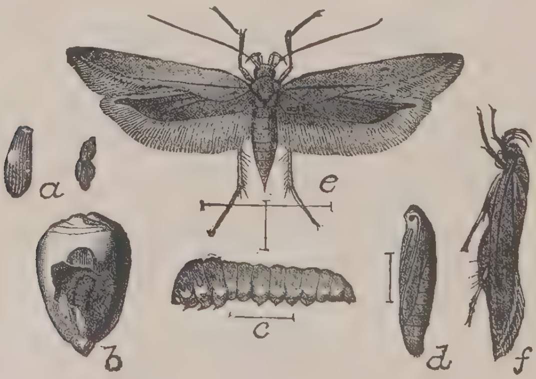


Fig. 180.—Grain moth. *a*, egg; *b*, larva in grain of corn; *c*, larva; *d*, pupa; *e* and *f*, adults. (U. S. Dept. of Agriculture.)

equally destructive to all kinds of grain, and since they will live over from year to year in the ordinary granary, the granaries and corn cribs should be gone over each year and thoroughly cleaned. This will kill many of the insects which would otherwise escape and cause damage another year. If the bins, cribs and granaries are cleaned out this way each year, well in advance of harvest time, it will help very much in keeping the "weevils" in control. Bins, cribs and granaries used for storing grains should also be built so that they can be opened as much as possible in the winter time, thus causing the temperature to fall as low as possible, for in this way the rapidity of the breeding of the weevils will be greatly reduced.

HOUSEHOLD INSECTS.

Not only are field crops badly injured by insects, but many kinds come into our houses and are very troublesome. Roughly speaking, these insects may be divided into four classes: (1) Those that are simply annoying by their presence; (2) those that are destructive to food, clothing, carpets, furniture, etc.; (3) those that are annoying because they bite or sting; (4) those that carry disease.

The first three of these groups are discussed here, the last, because of their very great importance, has been discussed in another connection. The actual loss occasioned by these household insects is frequently very great, but of vastly more importance is the annoyance that they cause.

Annoying Insects.—This group contains a few insect and insect-like animals that come into our houses frequently, and while the actual damage that they do amounts to nothing, their presence is often very annoying. Chief among these offenders are the so-called blow flies. These insects live in decaying matter, especially decaying meats; however, they frequently lay their eggs on meat that is fit for human food. There are two main kinds of blow flies. The larger metalic blue flies, commonly called "blue bottles" and the smaller greenish flies, called "green bottles." Both come into houses seeking food and places to lay their eggs. They also like to get into cool places out of the sun; for this reason they frequently come into basements and cellars. Because of their large size and their disagreeable buzzing, these flies are frequently more annoying to housekeepers than the smaller but vastly more dangerous house flies.

Destroying Food and Other Household Stores.—The insects in this group may be divided into two main divisions: Those that injure food and those that injure clothing, furniture and other household stores. The insects that injure food are especially apt to prove troublesome on the farm, where food is usually purchased in large amounts and kept for a considerable length of time. In cities and towns it is a constant fight to keep such insects out of pantries, because a fresh supply is apt to be brought in each day in groceries from the store. Most of these pests are small, and when once established in a pantry it is very difficult to get rid of them because they are adapted to living in cracks and crevices and can live for long periods of time without food if necessary.

Roaches.—Roaches (Fig. 181) have long been known as house pests in cities and towns that have water-works, and with the gradual introduction of water systems into country houses roaches or cockroaches have spread to them. They seem to require for their best development warm, moist situations, hence the connection there seems to be between the roaches and water systems. In all we have four different kinds of cockroaches that are common in houses in this country. These have been brought to us mostly from tropical countries. Among the four kinds of roaches that generally occur in houses are two classes, the small, yellowish-brown roach, called the croton bug or German roach, and the larger, darker forms, usually called "black bugs." However, all roaches have about the same habits. They feed at night and during the daytime they hide away in cracks and crevices. Roaches will eat almost anything that is soft enough for them to chew. They are especially fond of flour and other "starchy foods," also of chocolate. However, their greatest damage is not the amount they eat, but the amount they render unfit for food. They will frequently damage books very extensively, apparently to get at the paste in the bindings Roaches are essentially scavengers, and any method of control must take this into consideration. The first step in their control is to put all food beyond their reach as much as possible. This means tight bread and cake cans, tight flour bins and receptacles for other food.

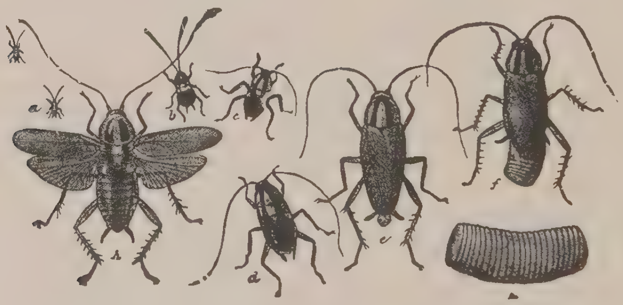


FIG. 181.—Cockroaches. *a*, *b*, *c*, *d*, nymphs at various stages of development; *e* and *h*, adults; *f*, adult laying eggs; *g*, eggs. (U. S. Dept. of Agriculture.)

Ants.—Next to cockroaches, ants (Fig. 156) are perhaps the most troublesome insects in pantries. As a general rule, there are three kinds of ants common in houses throughout the United States. The large black ants, the medium-sized brown or black ants and the small-sized red ants. All these forms are colonial in their habits, that is, they live in larger or smaller nests. These nests may be in the wall, in the basement or outdoors in the lawn. The first thing to determine, in attempting to control any kind of ants, is where they have their nest or nests and then treat these nests. Of all the ants that are commonly found in houses, the little red ant seems to be the hardest to control. They breed in small colonies in the walls of houses and outdoors and keep entering the house in apparently increasing numbers in spite of all one can do. In this case food can be stored on tables whose legs are set in shallow pans of glycerin.

Fruit Flies.—Wherever ripening fruit is exposed in the summer, it is attacked by fruit flies, which go under a variety of names, such as "sour gnats" and "vinegar flies." These names refer to the fact that fruit soon turns sour when attacked by these insects. The flies lay their eggs in decaying fruit and the maggots soon begin their work. These maggots attack ripe fruit and hasten the process of decay, hence they are often very destructive. Nothing much can be done for their control save keeping them away from ripe fruits. This is often hard to do as the flies can pass through the ordinary fly screen, and the maggots can crawl through very small cracks to get at such fruit. A great deal can be done by not leaving fruit, either fresh or canned, exposed any more than necessary.

Weevils.—There are a variety of small weevils or beetles that attack meal, flour and cereals of all kinds. Perhaps they do not destroy as much food as they render unpalatable by their presence. These fellows come from mills or groceries to pantries and once they gain entrance they are very hard to dislodge. All the infested meal or flour should be used up, either as human food, if not badly infested, or, if badly infested, it should be fed to stock.

Insects Destroying Clothes and Carpets.—Any kind of cloth containing wool or silk, also furs and feathers, are often seriously damaged by the following insects:

Clothes Moth.—There are two kinds of clothes moths in this country that commonly injure woolens, silks, furs and feathers. Aside from the fact that one kind of worm makes a case in which it lives and the other does not, there is really very little difference between these two kinds. Both are capable of doing great injury to clothes that are stored away during the summer time. Clothing that is worn constantly is not injured. It is the woolens and furs that are not much used in the summer time, when these insects are most troublesome, that are most likely to be damaged by them.

The control of these pests requires constant watchfulness. Unless clothes can be stored in very tight boxes or bags, they should be taken out every two weeks, hung out in the sun and given a thorough beating. This will knock off the eggs and worms and prevent any very great injury. If clothes are stored early in tight boxes or paper bags made especially for this purpose, they will be free from injury providing no eggs have been laid before the clothes are stored away. If clothes or bed clothes are stored in chests or trunks they should be fumigated a couple times during the summer.

Buffalo Beetle.—We have in this country two beetles whose worms are destructive to carpets, the buffalo beetle (Fig. 182) and the black carpet beetle. It is in the worm stage alone that they do injury. The eggs are laid by the adult beetle in the early summer among the fibers of the carpet, usually along the edges.

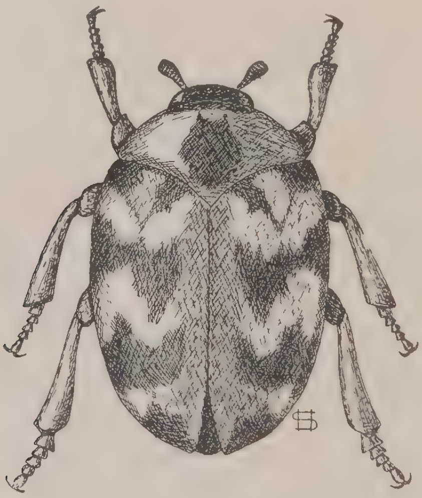


FIG. 182.—Buffalo beetle. (Author's illustration.)

Biting and Stinging Insects.—Much annoyance is caused about the house by certain pests which bite or sting.

Stable Fly.—This fly (Fig. 183) is commonly known as the "biting house fly" or "storm fly," from its habit of taking refuge in the house before a storm. It is larger than the common house fly and has a needle-like probosis with which it bites. It breeds in manure and its natural habitat is outdoors, but it also frequents stables, houses, etc. Its bite is painful and irritating but not poisonous.

Common Mosquito.—Throughout the United States the common mosquito is very abundant. It does not carry disease, but is most annoying. It breeds anywhere where water stands long enough for its eggs to hatch, in little slow-flowing streams, pools, sewers, rain barrels, tin cans, etc. The eggs are laid on the surface of the water in bunches; often several bunches will drift together, forming a raft. These eggs hatch into "wigglers" within a few days. After a week or ten days these wigglers change to tumblers. After a period of five or six days the skin of the tumbler splits open and the adult mosquito emerges. The adult is a medium-sized mosquito. Only the females bite, the males sip nectar from flowers and sap from leaves. Since about three-fourths of the life of a mosquito is spent in the water in the egg, wiggler and tumbler stages, our most effective means of destruction must be applied to these water stages. The malaria mosquito has been discussed on page 247.

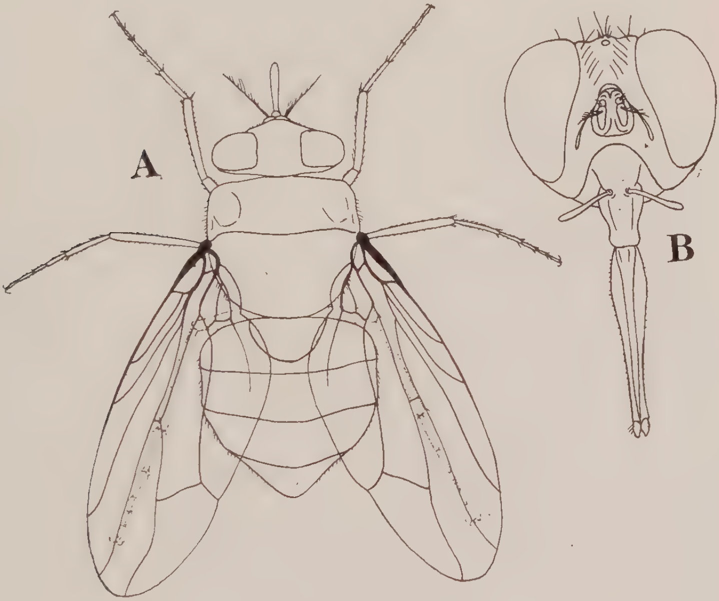


Fig. 183.—Stable fly. (Author's illustration.)

The Common Bedbug.—The bedbug (Fig. 184) is one of man's oldest and most faithful companions. It belongs to the same group of insects as does the stink bugs and squash bugs. This accounts for its disagreeable odor. It is smaller than most members of the group, flat, and fitted especially for hiding in the crevices of the bedstead. The eggs are oval, white in color and are laid in batches in cracks and crevices. They hatch in six to ten days and the active young are very light in color at first, but soon begin to gorge themselves with blood and take on a dark red or purplish color. Their mouth parts are fitted for lacerating and sucking. The underlip is greatly lengthened and the edges roll up, almost meeting above, thus forming a tube. Within this tube are four thread-like organs, which slide upon each other and lacerate the flesh of their unfortunate host, they then draw the blood through the tube.

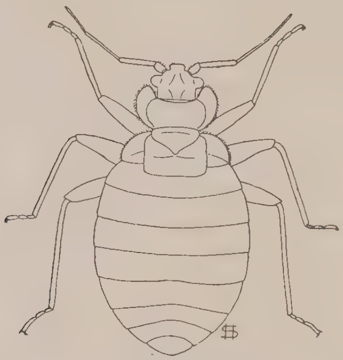


FIG. 184.—Bedbug. (Author's illustration.)

INSECT PESTS OF DOMESTIC ANIMALS.

Domestic animals, like crops, are often seriously troubled by insect pests. These pests cause injury in three different ways: By irritation, by sucking blood and in some forms by carrying diseases from one animal to another. Of these three important factors, we know the least about the last. Just as our knowledge of the human diseases carried by insects is rather limited, so is our knowledge of the diseases of livestock that are carried by pests even more limited.

Lice.—The lice infesting domestic animals are of two kinds: (1) Those that feed on hair, feathers, or scales of the skin, causing loss chiefly by the irritation they produce while crawling about among the hair or feathers; and (2) those that suck blood, causing loss in that way. The first group is (Fig. 134) largely confined to poultry and does widespread injury. The average farmer pays but little attention to this loss because it is a constant drain and not readily appreciated. The constant irritation causes loss of flesh and causes the production of eggs to fall off. The excess feed required for a flock of lousy birds if saved would soon pay for the necessary treatment of the birds, not to mention the increased laying that the hens would do. The lice (Fig. 135) that are usually troublesome to domestic animals belong to the second group and secure their food by sucking blood. The most important lice of this group are the hog louse, the blue louse of cattle, the horse louse and dog louse. Although cattle, horses and dogs are also commonly troubled by lice of the first group, they are not usually so serious as the blood-sucking lice. These lice are apt to break out in herds at any time, and usually get quite serious before they are noticed. Next to hog cholera, the hog louse is the worst pest of the hog, and the other lice are frequently very troublesome.

Horseflies.—There are two main kinds of horseflies (Fig. 185), the large black flies and the smaller flies with dark bands on their wings, which are often called ear flies, because they delight in attacking the ears of animals. Horseflies lay their eggs in swampy places and the larvæ are slender white worms that are frequently found in swamps.

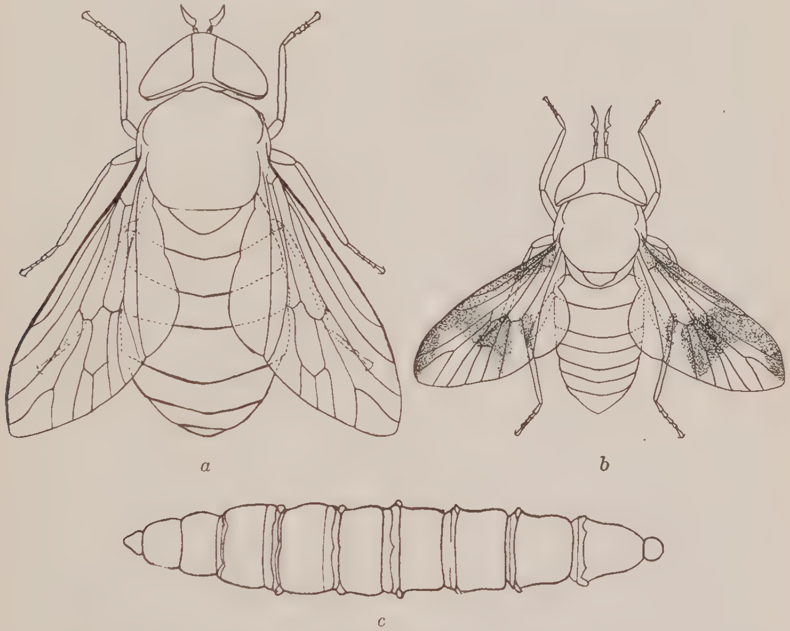


Fig. 185.—Horsefly and ear fly and larva. (Author's illustration.)

Horn Fly.—This is a small, blood-sucking fly, about one-half as large as the housefly, which is a serious pest of cattle, clustering on their backs in great numbers in the summer time. In this way they cause much loss of blood and perhaps even a greater loss due to the irritation of their bites. How much this loss is it would be difficult to say; however, the average dairyman says that the flow of milk falls off from one-fourth to one-half during fly time.

Horse Bots.—Horse bot flies are familiar to most farmers and are known variously as "nit stickers" or "nit flies." These flies are frequently seen about horses during the summer, laying their yellow eggs on the hairs of the legs and flanks. The horse in scratching or biting himself gets the larvæ into the mouth, whence they are swallowed and lodge in the stomach. They hatch out there in the form of bots and live until the following year. A few bots usually do little harm; however, when they get numerous they cause serious disturbances of the bowels, which is often confused with ordinary colic.

Ox Warble.—The ox warble is sometimes called "ox bot," "grub in the back" and "hide grub." This fly is quite similar to the horse bot; however, its grubs or maggots do not enter the stomach, but bore through the skin of the legs and flanks and work their way up to the back. Here they cause enlargements or "tumors." When the maggots or grubs are full grown, they work their way through the skin and drop to the ground. They then burrow into the soil, where they change to adult flies and emerge to lay eggs.

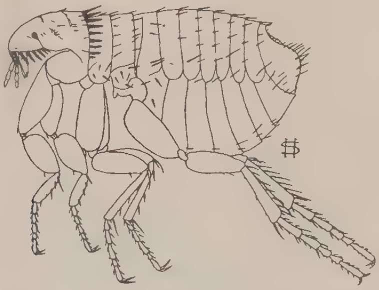


Fig. 186.—Adult dog and cat flea. (Author's illustration.)

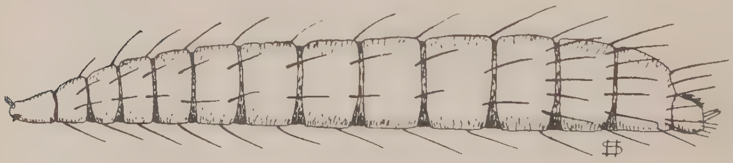


Fig. 187.—Flea maggot. (Author's illustration.)

The loss due to this fly is twofold: (1) There is the direct injury to the flesh and hide of the animal; (2) the loss in flesh or in milk caused by the continual torment of the animal by the flies. The meat of animals attacked by very many grubs is slimy and not very wholesome. However, perhaps the greatest loss is occasioned to the hide. The holes eaten through the skin of the animal cause a direct loss, as this part of the hide contains the most valuable leather.

Fleas.—Fleas are troublesome to several kinds of domestic animals, especially dogs and cats (Figs. 186 and 187). Frequently, because such animals have the run of the house, these pests become exceedingly troublesome in houses.

INSECT CONTROL.

The importance of insects as pests has led man to devise many methods for their control. A brief summary of the more important methods will be considered under two heads: (*a*) preventatives and (*b*) remedies.

Preventatives.—It is frequently much easier to prevent insect attacks than it is to control insects once they have gained entrance. These methods might be called collectively clean farming. Crop remnants left in the field after the crop is harvested harbor and protect insects during unfavorable seasons. These crop remnants may be easily destroyed by burning or plowing under, thus destroying many insects. Most of our destructive insects live on one crop or on a small group of related crops. If the same crop is grown in the same field year after year each succeeding crop falls heir to all of the pests of the previous years. Proper rotation of crops will aid materially in controlling insects. Anything that aids the plant in getting a good start in the spring and that aids the plant during the growing season is of great value in the prevention of insect damage. This would include the satisfactory preparation of the seed-bed, the proper time of planting, thorough cultivation and proper fertilization. In some cases it is possible to delay planting until the time for the insect to lay its eggs is past. In other cases where insects attack only a certain stage of the crop, such as the young plants or the fruits, it is often possible to plant the crop early so that the crop will escape injury.

Remedies.—Man has devised many remedies to aid him in his fight against insects. These may be grouped as stomach poisons, contact poisons, repellents and fumigants. *Stomach poisons* are used either as liquid sprays, as dusts or as baits and are effective only against chewing insects. The list of stomach poisons is a long one, including the arsenates of lead, calcium, magnesium, copper and zinc. Each poison has different characteristics. Some kill slowly and some rapidly and some are injurious to tender foliage, such as that of the bean and peach.

Contact insecticides include those insecticides which kill by coming into contact with the insect. They may be used against all kinds of insects, but are especially useful against the sucking insects which cannot be killed by stomach poisons. Contact insecticides include both liquid sprays and dusts. The principal materials used for this purpose include oils, soap or combinations of oils and soaps called emulsions, sulphur, especially in combination with lime in the mixture called lime-sulphur, and nicotine.

Repellents.—Many insects are repelled by various chemicals. These include oils with powerful odors such as creosote and certain oils like oil of citonella, oil of tar and oil of lemon.

Fumigants and Gases Which Will Kill Insects.—They are especially useful in buildings, storerooms, mills and in greenhouses, but are sometimes used to kill insects in the soil. The chief fumigant is hydrocyanic acid, made by mixing sodium or potassium cyanide with dilute sulphuric acid or by exposing calcium cyanide to the moisture of the air. Other common fumigants are nicotine, carbon bisulphide, sulphur dioxide made by burning sulphur, chloropicrin (tear gas) and paradichlorobenzene, used chiefly as a soil fumigant.

CHAPTER IX.

THE SEGMENTED WORMS.

(PHYLUM ANNELIDA.)

THE EARTH WORM
    Its structure
    Its economic importance
    Other worms closely related to the earth worm
THE LEECH

THE members of this phylum have the body distinctly divided into segments externally. The body is usually distinctly wormlike, *i. e.*, more or less smooth and cylindric. Appendages, either in the form of hair-like setæ or of muscular projections of the body called parapodia, are usually present. The head is generally distinctly set off from the rest of the body. It frequently bears tentacles, eyes and other sensory structures. The digestive system is complete. The mouth is anterior (Fig. 188). It leads into a muscular pharynx which may be protruded while the animal is feeding. The esophagus is usually short and narrow and leads into the intestine which continues to the posterior end of the body. The excretory system consists of a pair of much coiled kidney tubules, nephridia, for each segment. Internally each tube opens into the body cavity through a ciliated funnel-shaped nephrostome while externally it opens through the body wall by means of the excretory pore. Waste products are collected by the nephrostome and passed to the exterior through the tubule. The nervous system is usually elaborate, and consists of an anterior brain, dorsal to the esophagus, connected with the tentacles and eyes of the head, if these structures are present; a circumesophageal ring connecting the brain to the ventral subesophageal ganglion; and a chain of ganglia with a single ganglion in each segment. The sexes may be separate, or both kinds of sex organs may be found in the same individual (hermaphroditic).

The segmented worms are mostly marine, although some forms live in fresh water and some forms in damp earth. There are two distinct classes that are common—the Chætopoda, which have setæ and no suckers, and the Hirudinea, or leeches, which have suckers and no setæ.

THE EARTH WORM.

The earth worm, fishworm, or angleworm may be taken as an example of the class Chætopoda. It is a familiar worm to nearly everyone. It lives in rich, damp soil, which it devours for the sake of the organic matter which it digests. At night and on damp, cool days it comes out on the surface of the soil and crawls about search-for a mate. During dry weather it descends deeper into the soil.

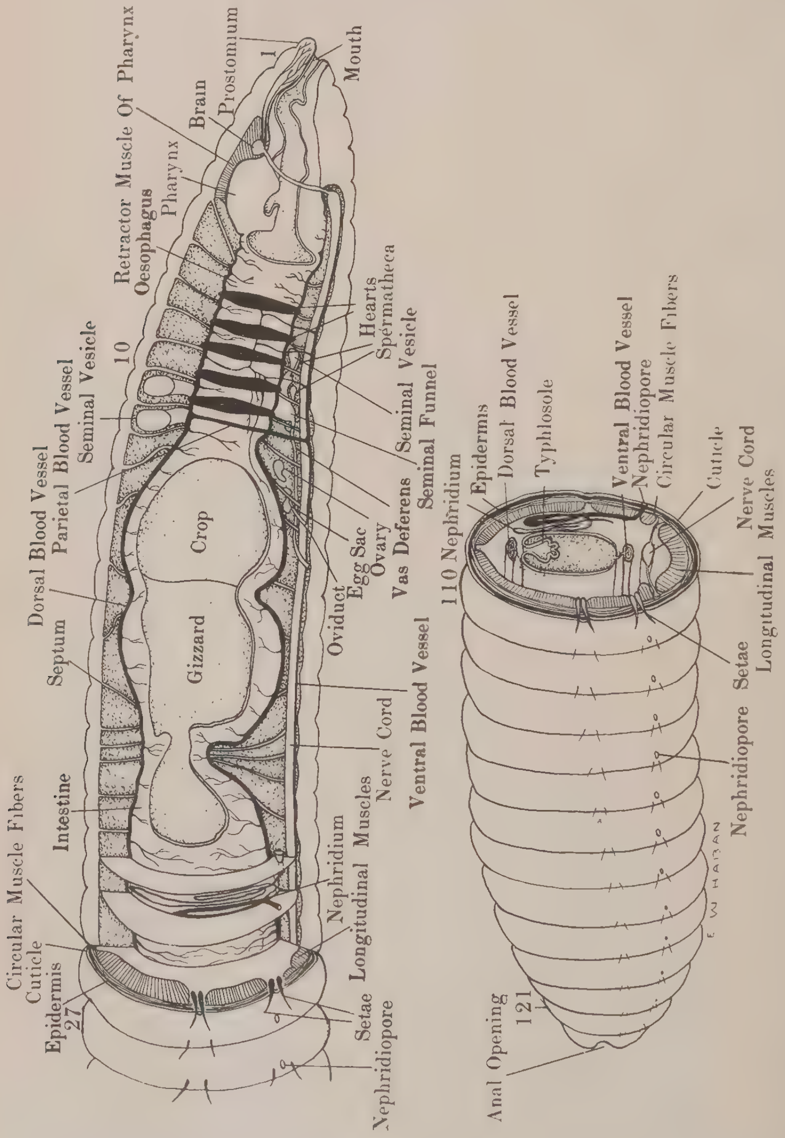

Retractor Muscle Of Pharynx
Prostomium
1
Mouth
Brain
Pharynx
Oesophagus
10
Seminal Vesicle
Parietal Blood Vessel
Dorsal Blood Vessel
Septum
Intestine
Circular Muscle Fibers
Cuticle
Epidermis
27
Crop
Gizzard
Hearts
Spermatheca
Seminal Vesicle
Seminal Funnel
Vas Deferens
Ovary
Egg Sac
Oviduct
Ventral Blood Vessel
Nerve Cord
Longitudinal Muscles
Nephridium
Setae
Nephridiopore
110 Nephridium
Epidermis
Dorsal Blood Vessel
Typhlosole
Ventral Blood Vessel
Nephridiopore
Circular Muscle Fibers
Cuticle
Nerve Cord
Longitudinal Muscles
Setae
Nephridiopore
121
Anal Opening
E W HARAN

FIG. 188.—Diagram of an earth worm, showing general structure.

The general shape of the earth worm is familiar to everyone and hardly needs to be described. The body is elongate, cylindric, slightly tapering toward either end. The anterior end is without evident head or distinct sense organs, although the worms are sensitive to light and retreat into their burrows when subjected to strong light. The setæ are short, but powerful, enabling the animal to retain its position in its smooth, round burrow. In fact, they are so powerful that the worm may be pulled in two rather than relinquish its hold. The setæ are also used as organs of locomotion, both on the surface of the soil and in the burrows. On the anterior third of the body there is a thickening known as the clitellum. This is a gland that secretes the covering for the eggs after they are laid. The earth worm is hermaphroditic and two individuals fertilize each other. The eggs are laid in a sac-like cocoon. The young worms on hatching resemble the adults in general appearances, but are much smaller.

The earth worms and their terrestrial and fresh water allies constitute the order Oligochæta which are characterized by having few setæ not borne on parapodia; head small, not distinct. The earth worms proper belong to the genera *Lumbricus* and *Helodrilus,* with usually more than 100 segments. They vary in length from 1 or 2 inches up to nearly 1 foot, and are found in rich soil or in swampy soil. The manure worm, *Eisenia fœtida* occurs in manure piles and has a fetid odor. The *Naidids* are small, transparent worms with a few segments and long setæ living in fresh water. The *Enchytræids* live in decaying vegetable matter along the sea coast or the shores of lakes and ponds. The tube worms are aquatic, constructing tubes in the bottom of lakes, ponds, salt marshes and along the seashore. The animals extend themselves from the tubes while feeding, but retreat when disturbed. The marine Chætopoda belong to the order *Polychæta.* They have numerous setæ borne on fleshy protuberances called parapodia. The head is distinct, frequently with tentacles, sometimes with eyes. One of the most familiar worms of this class is the clam worm, *Nereis spp.* These worms live in burrows in shallow water and are very active, feeding on a variety of small animals and furnishing in turn an important item in the food of fishes. The sea mouse, *Aphrodita hastata* is a short, thick-set worm which has the sides of the body covered with long, hair-like setæ. Hence, it is called the sea mouse. Some of the worms of this order construct elaborate tubes of sand or other particles cemented together by a secretion. Others secrete a calcareous tube which may be permanently attached to shells or rocks, or may be carried about by the worms to form a retreat in time of danger.

Economic Importance.—Earth worms are undoubtedly of very great importance in enriching the soil. These worms are partial to rich loams, and the number of worms per cubic foot might be taken as an index to the richness of the soil. Darwin made careful observations on the habits of earth worms and came to the conclusion that in rich soil earth worms bring to the surface castings equivalent to $\frac{2}{10}$ to $\frac{3}{10}$ inch per year. Since it is estimated that more than 50,000 earth worms may occur in an acre of surface soil, it can be readily appreciated that these worms are generally beneficial. Darwin recounts incidents of stony, infertile meadows being transformed into fertile meadows in a generation's time. While their value in this way may have been exaggerated, still they are of some importance to agriculture. Then who would dare to estimate the value of angleworms when dangling in front of wily trout; or who can figure the value of one of these wiggling fellows suspended on a bent pin or fish hook on a line attached to a pole in the hands of an eager, freckled-faced lad as he angles for the mighty pumpkin seed.

CLASS HIRUDINEA.

The leeches are flattened, segmented worms without setæ, but with an anterior and a posterior sucker (Fig. 189). The anterior or oral sucker leads to the mouth which is provided with powerful rasping teeth or a sharp-pointed proboscis which can penetrate the skin of their hosts. Leeches are mostly aquatic and only temporarily parasitic. Leeches attack all kinds of aquatic animals, and are frequently destructive to fishes, frogs and turtles. Many species attach themselves to bathers in fresh water, producing painful sores. In Ceylon there is a species of land leech that is said to be very troublesome on the coffee and spice plantations, attacking the laborers and sucking blood. These leeches are very slender and readily penetrate clothing. The natives anoint their bodies with various kinds of substances to repel these troublesome pests. The medicinal leech is still used for blood-letting, although this method is not as common as formerly when blood-letting was considered a sort of cure-all.

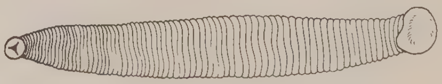


FIG. 189.—Leech.

CHAPTER X.

THE MOLLUSCA AND THE SHELL-FISH INDUSTRY.

(Phylum Mollusca.)

- The Principal Types
  - Pelecypoda
  - Gasteropoda
  - Cephalopoda
- Bivalves
  - The oyster
    - Its structure
    - Its life history
    - Oyster culture
    - Oysters as food
  - Clams
    - Soft clams
    - Hard clams
    - Method of collecting
    - Economic importance
  - Sea mussels
    - Habitat
    - Economic importance
  - Scallops
    - Habitat
    - Method of collecting
    - Economic importance
  - River mussels
    - Habits
    - Economic importance
    - Processes in manufacture of buttons
      - Dredging
      - Cutting
      - Polishing
      - Drilling
      - Carding
  - Shipworms
    - Habits
    - Economic importance
  - Pearls
    - How formed
    - Economic importance
- Gasteropoda
  - Edible snails
    - How raised
  - Slugs
- Cephalopoda
  - Squids as food

The *Phylum Mollusca* contains the typical shell fish. The number of species in this phylum is very large. It is next to the Arthropoda, the largest phylum in the animal kingdom. The forms are also very diverse, so that it is rather difficult to give a definition that will apply to the phylum as a whole. Usually there is a muscular locomotary organ or foot, an unsegmented visceral mass or body frequently enclosed in a mantle cavity, gills and a shell. The animal is usually bilaterally symmetrical, although the shell is frequently asymmetrical. The digestive system is complete. The nervous system is frequently much reduced, with simple sense organs. It is much more elaborate in the more active forms. The variations in all these structures are so numerous and so diverse that it is better to discuss the modifications under the various classes.

THE PRINCIPAL TYPES.

There are three principal classes in the *Phylum Mollusca*—the Pelecypoda, the Gasteropoda and the Cephalopoda.

Class Pelecypoda.—This class contains the typical bivalves, that is molluscs with two shells (Fig. 190). It includes such common forms as the oyster, the clams, the sea mussels, the river mussels and many others.

The shell in this class consists of two valves which are joined together by the *hinge ligament,* which opens the shell. In addition, various shaped projections called *teeth* are usually developed along the dorsal margin in the region of the hinge. These teeth prevent the valves from rotating on each other. The valves are closed by means of muscles which stretch from one valve to the other, and work against the hinge ligament. When the muscle contracts the valves close and when they relax the elasticity of the ligament causes the valves to open.

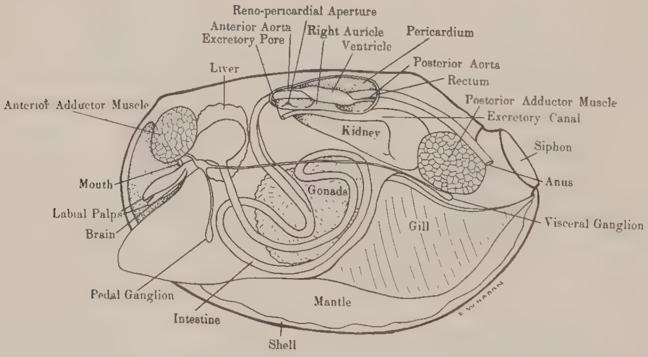

Reno-pericardial Aperture
Anterior Aorta
Excretory Pore
Right Auricle
Pericardium
Ventricle
Liver
Posterior Aorta
Rectum
Anterior Adductor Muscle
Posterior Adductor Muscle
Excretory Canal
Kidney
Siphon
Mouth
Anus
Gonads
Labial Palps
Gill
Visceral Ganglion
Brain
Pedal Ganglion
Mantle
Intestine
Shell

FIG. 190.—Diagram of the general internal structure of the river mussel.

The animals of this class have a somewhat wedge-shaped or hatchet-shaped *foot,* hence the name *Pelecypoda.* The *mantle* is usually well developed, with the *mantle cavity* inclosing the *visceral mass* and communicating with the exterior through a *ventral* or *incurrent syphon.* The gills are usually well developed and frequently consist of two pairs, which are broad and laminated.

The digestive tract is complete. The *mouth* lies dorsal to the foot and is frequently guarded by *labial palps.* A distinct enlarged cavity, the *stomach,* is usually developed and the intestine is more or less coiled. The *anus* opens into the *dorsal* or *excurrent* syphon. The sexes are usually separate. The spermatozoa are carried to the eggs by currents. The fertilized eggs are frequently retained in the gills of the female, which act as *brood pouches.*

Class Gasteropoda.—This class includes the marine snails, the land and fresh water snails (Fig. 191) and the slugs. Typically the members of this class have an external, spirally coiled shell, into which the animal can retreat in time of danger. The external shell is absent in the slugs. The body is broad and elongate and bears at the anterior end two pairs of sensitive *tentacles*. The second pair of tentacles bears the eyes at the tips. The foot is broad and flat and creeps over the surface with the aid of a slimy or mucous secretion. The mantle cavity is reduced and opens to the exterior through the *respiratory aperture*. The mantle cavity also contains the elaborate gills which are spread out over the roof of the mantle cavity. In the terrestrial and fresh water snails and the slugs the mantle cavity is provided with a much branched blood vessel and the cavity performs the function of a lung. The mouth is anterior and is provided with a file-like *radula* for rasping away particles of food which are swallowed. The intestine coils into the visceral mass and the anus usually opens into the mantle cavity near the respiratory aperture. The sexes are sometimes separate and sometimes united in the same individual. These hermaphroditic snails usually require cross fertilization. The fertilized eggs are laid externally and development is direct. The nervous system is fairly well developed and the tentacles are sensitive to light and touch and perhaps to smell.

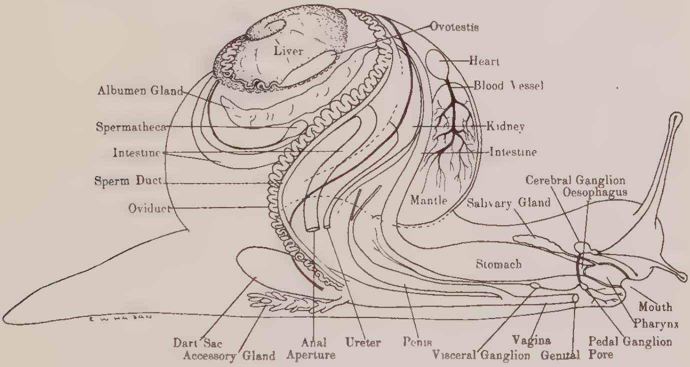

Ovotestis
Liver
Heart
Blood Vessel
Albumen Gland
Spermatheca
Kidney
Intestine
Intestine
Sperm Duct
Cerebral Ganglion
Oesophagus
Oviduct
Mantle
Salivary Gland
Stomach
Mouth
Pharynx
Dart Sac
Accessory Gland
Anal Aperture
Ureter
Penis
Visceral Ganglion
Vagina
Genital Pore
Pedal Ganglion

FIG. 191.—Diagram of the general internal structure of the land snail.

Class Cephalopoda.—This class includes the squids, the cuttlefish, the devil fish or octopus and the nautilus. The body of the members of this class is usually divided into a distinct ventral head and a dorsal visceral mass enclosed by the thick mantle. The head bears eight or ten or more *arms* or *tentacles*, which in the common forms are provided with *suckers*. The head also bears a pair of eyes which are very complex. The nervous system is more highly developed than in the other mollusca. With the exception of the chambered nautilus, there is no external shell save in the female of the paper nautilus, where it serves as a receptacle for the eggs. The internal shell is the well-known cuttle-fish bone and is more or less reduced. Water is drawn into the mantle cavity through a *syphon* and bathes the gills. The digestive system is rather elaborate, and the mouth, which lies at the base of the tentacles, is provided with two jaws which form a structure somewhat like a bird's beak. Some forms have a distinct *anal gland*, called the *ink sac*, which opens into the intestine near the anus. This gland secretes a brownish-black pigment when the animal is threatened by an enemy and clouds the water, forming a smoke screen. This may allow the mollusc to escape its enemy. The sexes are separate. The sperms are enclosed in an elaborate sac-like structure called the *spermatophore*. They are transferred to the females by means of one of the tentacles, which becomes modified for this purpose.

THE BIVALVES.

The term shell fishes is a general term including all marine animals which are used for food, excepting the vertebrate fishes and turtles. In this sense it includes the crustaceans like the lobsters, shrimps and crabs that are used for food. In a stricter sense, the term shell fish might be used for the edible mollusca, but for these we prefer to use the name bivalves. Although not all of the molluscs that are used for food in all parts of the world have two valves.

The oysters, the clams, the sea mussels, the scallops, the snails and in the Orient the squids are used for food. Most of these forms are considered delicious morsels by various peoples, and they furnish a considerable, if not inexhaustible, supply of food to the tables of the world. It has been suggested that if proper cultural methods were employed, the sea and adjacent sounds, rivers and tidal flats would furnish acre for acre several times as much food as the land furnishes. In the past, however, man has usually been content to harvest what Nature has furnished. The methods of harvesting have usually been very destructive, so that Nature has not been able to maintain a sufficient supply of these edible bivalves to satisfy the markets. The only hope is that the demand will eventually force upon us proper methods of culture before the natural beds are completely exhausted.

The Oyster.—The oyster is the most important food bivalve in the United States. It occurs on the Atlantic and Gulf Coasts, from Massachusetts to Texas, living in brackish water in bays, sounds and rivers. Vertically it is distributed from high-water level to a depth of 100 feet or more, but most commercial beds occur in water not over 10 to 15 feet deep. In the average season about 30,000,000 bushels of oysters are harvested.

Structure of the Oyster.—The oyster has two shells. The shape is very variable, depending upon a number of factors, crowding being important. Characteristically the shape is elongate triangular and somewhat curved. The oyster is attached by the left shell which is deep, the right shell being flat. Externally the shell is roughened, often showing concentric lines of growth and radiating ridges. Internally the shell is usually quite smooth and is lined with a layer of mother-of-pearl which may be white or colored. The two valves of the shell are hinged at the small end by means of the hinge ligament which tends to open the shell when the muscle is relaxed. Internally the shell is lined by a thin membrane called the mantle. There is a single large round adductor muscle near the center of the shell. This pulls the two valves together and holds them together in times of danger. In addition there are four pairs of flap-like structures. The two larger pairs are gills concerned with respiration. The two smaller pairs, palps, surround the mouth and aid in directing food into the mouth. The rest of the space inside the valves is filled with the body mass which contains the organs of digestion and circulation and the sex organs. The digestive system is relatively simple. The mouth opens at the small end of the shell and is surrounded by the palps. The esophagus is short and leads to the stomach. The stomach receives the secretions from the digestive gland or liver. This is a dark-colored conspicuous organ just beneath the stomach. The intestine is elongate coiled or looped and opens into the mantle cavity just above the adductor muscle.

By means of the cilia on the gills and palps a current of water is created. Part of this water passes through the gills and gives up its oxygen and takes on carbon dioxide. The rest of the water, containing microscopic animals and plants which constitute the bulk of the food of the oyster, is carried forward to the mouth, where the organisms are swallowed and then digested in the stomach.

The reproductive organs occupy much of the body mass between the mouth and the adductor muscle. The single reproductive duct opens below the adductor muscle. The sexes of the oyster are separate. The sperms and ova are produced during the warmer parts of the year, and pass through the reproductive duct into the mantle cavity and thence into the water, where fertilization occurs. The fertilized egg develops into a swimming larva. This larva swims about in the water for about two weeks, but eventually settles down and attaches itself by the left valve to some suitable object, such as other oysters or the shells of other bivalves, to stakes or piles, to the roots of trees, in fact to practically any firm object in the water. After the larvæ become "set" growth commences.

They reach a marketable size in from two to four years, but may live much longer than this.

Oyster Culture.—In the United States oyster culture consists principally of providing an abundance of mature oysters to furnish a sufficient supply of free-swimming larvæ and providing an abundance of suitable material, cultch, for the larvæ to set on. Oyster shells are usually used as cultch at the present time. Suitable areas for oyster culture are staked out, usually near natural oyster beds to insure an abundance of mature oysters. Oyster shells are then scattered over the area for cultch. After the spat has set they may be examined from time to time, and if overcrowding occurs the oyster shells with the spat may be broken up and transplanted to more favorable locations. When the crop is of marketable size the oysters are harvested. Various methods are used to harvest oysters in this country. Most oysters, however, are harvested either by tonging or dredging. Oyster tongs are made by fastening together two long-handled rakes like a pair of scissors. The teeth of the rakes are so fitted that they form a basket when pushed together. The tongs are worked over the bottom, and when the basket is full of oysters the tongs are pulled up and the oysters emptied into the boat. A dredge consists essentially of a stout iron rake with a coarse bag or net attached. The rake loosens the oysters from the bottom, which are then collected in the net. When the net becomes full it is hauled in and emptied into the boat. Dredges may be operated by hand or by an engine.

Oysters as Food.—Oysters are esteemed for their fine flavor. In food value they rank somewhat below the poorer fish and at present prices they are to be classed more as a luxury than as a staple. However, the importance of flavor in foods is not to be neglected. Therefore, oysters have a very important place in the diet. Oysters also contain valuable mineral elements, especially calcium and iodine.

Marketing the Oyster.—Oysters are sent to market in three different ways—in the shell, shucked and canned. Oysters in the shell are sent to market to be served raw on the half shell or to be roasted in the shell. They are usually shipped in barrels or large bags without ice. Oysters from certain regions, especially Blue Point, Long Island and Lynnhaven Bay, Virginia, have gained a great reputation for fine flavor and are much esteemed.

Shucked oysters constitute the bulk of the oysters sent to market. These oysters are removed from the shell and packed in tin vessels which are packed in ice.

Canned oysters are first steamed and then opened. The meats are placed in cans and the cans filled with brine. After the cans are filled and capped they are steamed, then cooled and labeled, after which they are ready for the market.

Enemies of the Oyster.—In the more northern waters the starfish is one of the principal enemies of the oyster. The method of destroying the starfish is discussed on page 300. The oyster drills are small, snail-like molluscs, with sharp, rasp-like tongues (radulæ), by means of which they can bore a small hole through the oyster shell and then suck out the oyster.

Clams.—The name clam is given to a large number of different bivalves, especially to those that live in the between tide zone and more especially to those that are used as food. In the eastern United States two species, the soft, or long-neck clam, *Mya*, and the hard clam, or little neck, *Venus*, are extensively used for food. On the Western Coast other clams, especially the great blue clam, *Schizothærus*, the little neck, *Paphya*, the hard clam, *Saxidomus*, and the razor clam, *Siligua*, are used for food.

The Soft Clam.—This clam lives principally in the great tidal flats north of Cape Cod, although any beach or area that is exposed at low tide will support this species. The shell is somewhat thinner and softer than the other species of clam, hence the name soft clam. The syphon is very long, hence the name long neck clam, and the clam often burrows into the sand to a depth of a foot or more. When the tides are in, water laden with food and oxygen is drawn in through the inhalent tube and the water flowing out through the exhalent tube carries the wastes away from the body. When the tide is out the syphon is withdrawn and a characteristic hole is left in the mud.

The sexes are separate in the clam as in the oyster. The eggs are fertilized in the water and swimming larvæ are produced. The larva settles down on the bottom and secretes a byssus thread, which fastens it to the bottom. For a period it lives thus anchored to some solid object creeping about over the surface as far as the byssus will permit. Sooner or later it burrows into the sand or mud. The number of these young occurring under favorable conditions is almost beyond belief. Kellogg records the fact that 2486 young clams ready to burrow have been sifted from a square foot of sand, and 1937 clams, averaging ½ inch in length, have been taken from an area of the same size, while a similar area produced 163 clams from 1 to 2 inches in length. The soft clam usually reaches marketable size in two years.

The Hard Clam.—South of Cape Cod the soft clam is replaced in importance by the hard clam (Fig. 192), so-called because the shell is much thicker and firmer than in the soft clam. It is also commonly called the little neck clam because the syphon is much shorter than in the long neck clam. The hard clam lives to a limited extent in the between tide zone, but is found more abundantly in the deeper water. Since the syphon is short this clam does not burrow very deeply. The life history of this clam is essentially the same as that of the soft clam.

Methods of Collecting.—Both the soft and hard clams are dug from the sand and mud by means of a short-handled, long-tined clam hook, which resembles an ordinary potato hook. Because the hard clam lives more abundantly in deep water, it is usually collected from boats, sometimes by means of oyster tongs or dredges, but more frequently by long-handled rakes. In some localities, where the water is shallow, hard clams are treaded out by wading about in the water until a clam is touched by the foot.

Economic Importance.—Clams have long been used for food, especially along the coast of New England during the summer after the oyster season is over. Recently these delicious bivalves have come into more favor and the demand for them has been very much greater. The soft clam cannot be shipped long distances alive, hence the markets at some distance from the coast have been supplied by canning the clam meat or the clam broth and with clam chowder. The hard clam, on the other hand, can be shipped long distances if kept chilled and most of these clams are sent to market alive.

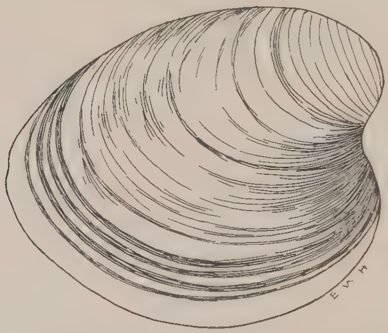


FIG. 192.—Hard clam. *Venus mercenaria.*

Very little has been done in the way of clam culture, chiefly because the tidal flats are usually considered public property. They are easy to cultivate, however, and under proper conditions clam culture would be as profitable as oyster culture. Thus large areas not suitable for any other crop would be made productive.

Sea Mussels.—The sea mussel (Fig. 193) *Mytilus spp.* is one of the most abundant bivalves along the Atlantic Coast, living in the between tide zones, often covering vast areas very densely. They are somewhat oyster-shell-shaped and in some species have prominent radiating rays. The sea mussels are attached by bundles of byssus threads.

In Europe the sea mussels are used for food and in certain regions mussel culture is carried on quite extensively. In this country they have never been esteemed, although it is difficult to understand why this abundant sea food has been neglected. Perhaps the chief reason is that it cannot be shipped for any distance satisfactorily. The flavor, while different from that of the oyster, is in no way inferior. This bivalve is so abundant and could be cultivated more easily than the oyster. Therefore, there is every reason for believing that as the other sea foods become scarcer, the sea mussels will become more and more important.

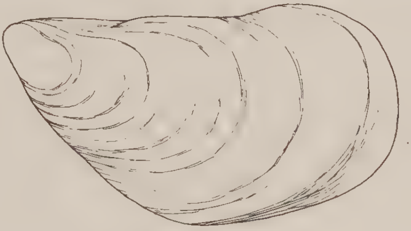


FIG. 193.—Sea mussel. *Mytilus sp.*

Scallops. –The scallops, *Pecten spp.* (Fig. 194) are free-swimming bivalves, and do not lie buried in the mud as the clams do, nor are they attached as the oyster and sea mussels. Their method of swimming is a rather peculiar form of locomotion. By opening the valves water is drawn in, the edges of the mantle are provided with a fold which holds the water so that the water is forced out through a tube near the hinge when the shell is closed by the powerful adductor muscle. In this way the scallop swims in a zig-zag course. The shell of the scallop is one of the most beautiful of the bivalves. It is nearly circular in outline, with deep, radiating lines and prominent ears at the hinge line.

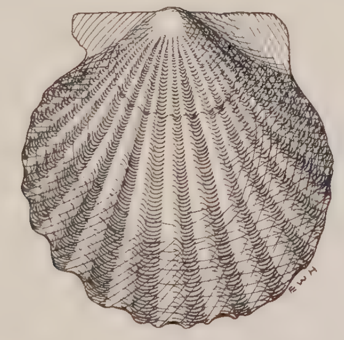


FIG. 194.—Scallop. *Pecten sp.*

In the scallop it is only the adductor muscle that is used for food. This is a very wasteful process as the parts that are thrown away could be used for food just as similar parts are used in the oyster and clam.

Scallops are collected in deep water by using dredges and in shallow water by means of a coarse net supported on an iron frame. This is pushed in front of the operator as he wades in the water and is known as a pusher.

River Mussels.—The river mussels are relatively large molluscs with heavy shells. They are found in practically all the fresh water streams and lakes in the United States, but those of economic importance occur chiefly in the streams of the Mississippi Valley, flowing through limestone regions. River mussels are provided with two elongate shells fastened together by a strong dorsal hinge ligament and strong anterior and posterior adductor muscles. At the anterior end there is a muscular foot, by means of which the animal can plow its way through the mud on the bottoms of streams or ponds. At the posterior end of the body there is a ventral incurrent syphon which brings in water with food and oxygen. The food is passed on to the mouth. The oxygen is removed by the water passing through the gills where it receives the carbon dioxide and then passes out through the dorsal excurrent syphon. If the mussel is disturbed the foot is withdrawn and the shell tightly closed by the two adductor muscles. After remaining quiet for a period the shell is slowly opened by the hinge ligament, when the adductor muscles are relaxed, the foot is protruded and feeding begins again. In Nature the mussels are set obliquely to the bottom with the anterior end of the shell more or less buried in the mud.

The breeding habits of our common river mussels are very interesting. In most species the sexes are separate. The sperms are passed out into the water and are carried into the incurrent syphon of the female. The fertilized eggs are retained in the brood pouches, a part of the gills. The fertilized eggs develop into larvæ known as glochidia. A typical glochidium consists of a pair of shells hinged together which may be closed by a single adductor muscle. After the glochidia are full grown they are expelled from the brood chamber of the mother. If they come in contact with the gills or fins of a fish they attach themselves by clamping the two valves of the shell on the edge of the gill or fin. The glochidia of some species of mussels have been found on only a single species of fish, while other glochidia seem to be able to attach themselves and develop on a number of fishes. The glochidia may remain attached to the fish for from ten days to two weeks or longer. After this period they drop off the fish and gradually develop the adult form.

Economic Importance.—The shells of the river mussels are used in manufacturing the common pearl buttons of commerce. This industry has developed in this country since 1890. At the present time it is estimated that about 50,000 tons of shells are gathered each year with a value close to $1,000,000. The finished product has a value of about $5,000,000.

The Processes in the Manufacture of Buttons.—The processes in making buttons may be classified as follows: collecting, cooking, cutting blanks, polishing, drilling, sorting and carding. Each process will vary somewhat in different regions, but the more typical processes may be described as follows:

Collecting.—Mussels are collected in various ways: by means of crowfoot hooks on a bar, by dredges, by tongs, by forks, etc. The crowfoot bars are usually iron pipes several feet long, to which are attached lines carrying hooks with four prongs. These hooks catch in the syphons of the mussels as the bars are dragged over the beds. The mussels close their shells and hold fast until the bars are lifted. The dredges and the tongs are similar in general arrangement and use to the tools of the same names that are used for collecting oysters. The fork, usually a long-tined coke fork, is used only in shallow water, the operator wading about in shallow water and scooping the mussels into the boat.

Cooking.—After the mussels have been collected they are taken ashore and cooked, usually by steaming, the meats removed and the shells sorted and sent to the factory for cutting blanks.

Cutting the Blanks.—The blanks of different sizes are cut from the shells by means of a tool resembling a lathe, which is furnished with a tubular saw. By careful manipulations a large number of different blanks may be cut from a single shell.

Polishing.—After the blanks are cut they are placed in a churn-like tumbler with water and fine sand or pumice stone to be polished. The horny, dark-colored outside layer is removed from the blanks by passing them through grinding machines, which also reduce the blanks to a uniform thickness.

Finishing.—After polishing the blanks are ready to be finished. This is usually done by a single automatic machine which receives the disk-like polished blanks and turns out the finished button. The finishing process really consists of two distinct processes, facing and drilling. The process of facing consists of grinding the surface of the blank to form a design. After the face is complete the holes through which the thread passes in sewing on the buttons are drilled.

Carding.—After the buttons come from the finishing machine they are given another polishing, sorted, fastened to cards and packed in boxes ready for market.

Shipworms.—Shipworms are peculiar worm-like, wood-boring bivalve molluscs. There are two species in the United States, the American shipworm and the European pileworm. In their general habits these two animals are quite similar, but the pileworm seems to be much more destructive than the shipworm. Both animals damage piles, boats and all wood that is exposed to sea water, by boring into it. Frequently wood is completely riddled by these holes. The shipworms are small bivalves with much elongate syphons, which bore into wood for protection. The anterior end of the body is protected by a pair of valves. These valves are provided with minute teeth, and by rotating the valves through an arc of a circle the wood is rasped away. The shipworm may derive some nourishment from the wood, but most of the animal's food is derived from microscopic animals which are brought in by the currents of water through the syphons as in the river mussels and the clams.

The eggs are fertilized in the gills of the female by spermatozoa which are brought in through the incurrent syphon. These eggs develop into swimming larvæ which swim about until they find suitable unprotected wood. They then bore into the wood with the syphons extended through the opening. As the animal grows it extends its burrow by rasping away the wood at the bottom of the hole, using the foot as a sucker and the two valves of the shell with their sharp teeth as a drill. The minute shavings which are rasped off are passed through the digestive track and out through the excurrent syphon. As the animal extends its burrow the syphons are extended and the burrow is lined with a thin calcareous shell. Single burrows may extend for several inches or even for a foot or two.

Economic Importance.—In the days of wooden ships the shipworms did much damage to vessels of all kinds. At the present time their damage is confined largely to small wooden boats, to piles, wharves and spars. The European pileworm is much more destructive than the American shipworm in this country. This is not only because it breeds much more rapidly, but also because it can live in water that is only slightly brackish. Fortunately the pileworm seems to be present in only a few localities. It has done more damage apparently in San Francisco Bay than in any other region. Careful estimates indicate that the repairs made necessary because of the damage to wharves and piles during the years of 1920 and 1921 amounted to more than $15,000,000. To prevent the damage by this pest it is recommended that all wood that will be exposed to attacks should be thoroughly creosoted and that all old structure should be thoroughly examined and damaged timbers replaced. Abandoned wharves and similar structures should be removed, as otherwise they furnish excellent places for these pests to breed in numbers.

Pearls.—Pearls are formed by various species of molluscs. The river mussels which are used for making pearl buttons furnish a considerable number. Occasionally pearls are found in the edible oyster and in the clam, but for the most part they are small or of little value. However, the majority of the pearls are furnished by the pearl oysters which occur in the warmer oceans of the world. The principal regions are Ceylon and in the Persian Gulf. Formerly the pearl oyster was collected entirely by naked divers, who descended to the bottom, usually about 50 feet by means of a weighted line with a basket in which the pearl oysters were placed. Naked divers could remain under the water only about a minute, however, and more recently divers have been equipped with diving suits which permit them to remain for a much longer time. After a boat load of pearl oysters have been collected they are brought to shore and placed in bins where the animal is allowed to decay. The shells and flesh are then carefully worked over to discover the pearls. The shells of the pearl oyster are valuable for the mother-of-pearl which is variously cut and carved to make knife handles, buttons and other ornaments.

The substance of the pearl is the same as the delicate lining of the shell known as mother-of-pearl. This substance is secreted by the mantle. Apparently any foreign object, such as a minute grain of sand, a parasitic worm or any similar object may stimulate the mantle to secrete a layer of mother-of-pearl over the object, thus reducing friction and irritation. Subsequent layers will be added to this and the pearl will grow larger and larger. Most of the pearls secured are less than $\frac{1}{4}$ inch in diameter, although irregular pearls 1 or more inches in length have been found. The value of pearls depends chiefly upon their luster, upon their size and upon their perfect spherical shape, although pearls of unusual shapes sometimes bring fancy prices because of their fancied resemblance to sacred objects. The Chinese introduce figures of the Budda into the shell of the pearl oyster and leave it until the figure is covered with a layer of pearl.

GASTEROPODA.

The gasteropoda are of little economic value in this country. Slugs are sometimes injurious in gardens and greenhouses, and are sometimes troublesome in basements of houses and elsewhere, because of the slimy trail they leave wherever they crawl.

Snails are considered a great delicacy by the French. They are collected in the woods and fattened in pens by feeding with meal, bran and vegetables.

The abalones are much esteemed on the Pacific Coast. They are marine gasteropods of considerable size. They have a flattened, conical shell. The animal clings to the rocks in shallow water by means of the large muscular foot. The muscle is sliced and fried much as oysters are prepared. Some of the meat is dried and exported to the Orient chiefly, where it is used for flavoring soups. The shell is lined with a beautiful iridescent mother-of-pearl layer and is used for buttons and other ornaments.

CEPHALOPODA.

The cephalopods (Fig. 195) likewise are not of any very great economic importance. Formerly the brown dye or paint, known as sepia, was manufactured from the ink bag of the cuttlefish, but this dye has been largely replaced by other products. Sepia is used especially for making water-color paints and in the Oriental countries for making ink.

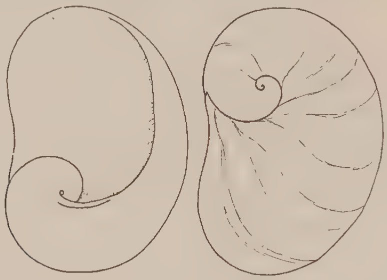


Fig. 195.—A nautilus.

The shell of the cuttlefish is used for grit for cage birds and in this form the cuttlefish is familiar to nearly everyone.

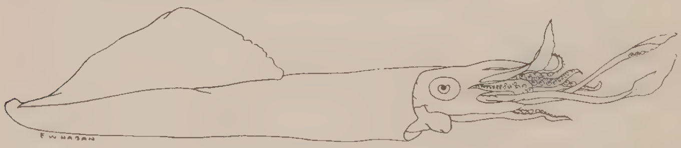


Fig. 196.—Squid. *Loligo sp.*

Squids (Fig. 196) are also used extensively for fish bait along the Atlantic Coast, especially by the cod fisherman. According to the Bureau of Fisheries, about 3,000,000 pounds are used each year for this purpose. Cephalopods of various kinds are used for food, especially by the Italians and the Oriental peoples.

CHAPTER XI.

THE ECHINODERMS.

(Phylum Echinodermata.)

Typical Examples	Economic Importance
The starfish	The starfish and the oyster
The brittle stars	
The sea urchins	
The sea cucumbers	
The sea lilies	

The animals of this phylum are marine and are known commonly as starfish, sea urchins, sea cucumbers, etc. One of the most evident characteristics is the apparent radial symmetry of the more common species, with the parts arranged in fives or multiples of five. A closer examination will show, however, that this apparent radial symmetry is superimposed upon a less evident bilateral symmetry. A study of the life history also shows that these animals have larvæ which are bilaterally symmetrical. The most characteristic structure of these unusual animals is the *water vascular system*. This system is an elaborate arrangement of canals, vessels and tube feet. The chief function of this system is locomotion in the free-moving forms, but it also serves to capture and hold the prey. In some forms the tube feet are highly sensitive and are important organs of touch. In other forms these organs may aid in respiration and excretion.

The water vascular system opens to the exterior through the pore plate (madreporite), a sieve-like plate which admits water freely. In typical forms the pore plate opens into a stone canal which leads to a ring canal around the oral opening. This ring canal sends off radial canals, usually five in number, situated near the oral surface of the arms in the forms that have arms. From the radial canals numerous paired lateral canals are given off. Each lateral canal ends in a structure called the ambulacrum. Each ambulacrum consists of a bulb-like or sac-like ampulla and of a tube-like, extensible tube foot. The tube feet are hollow but well provided with muscles; typically they have sucking disks at the end. By the contraction of the ampullæ liquid is forced into the tube feet. Then if the sucking disks become attached to a solid object and the muscles contract, the tube feet are retracted, the liquid is forced back into the ampullæ and the animal moves along. The liquid in the water vascular system is not just plain sea water, but contains material secreted by certain sac-like glands attached to the ring canal.

The bodies of the echinoderms are supported by dermal calcareous plates. These plates often support spines, and it is from this character that the name of the phylum is formed, being derived from two Greek words, meaning an animal with a skin like a hedge hog. In some forms the spines are simple, conical protuberances. In other forms, like the sea urchins, they are elongate and conceal the form of the body. Certain of these spines are modified into pincer-like structures (pedicellariæ). It is supposed that the function of the pedicellariæ is to prevent the attachment of plants and animals. Thus the surface of the animal is kept clean.

The internal organs are generally arranged in a radial manner to correspond to the radial arrangement of the external parts. The digestive system is usually complete. Typically it consists of a large oral opening on the oral surface, a short esophagus, a sac-like stomach which is eversible in the starfish and can be forced through the oral opening to engulf food. The intestine is short and has a number of sac-like appendages attached to it. The most important of these appendages are the hepatic cæca, which are very large in the starfish, almost completely filling the arms. The hepatic cæcæ secrete a digestive fluid. The intestine opens to the exterior through the anal opening, which is usually placed in the center of the aboral surface, the surface opposite the oral opening.

The sexes of the Echinodermata are usually separate. The eggs are laid in the sea water and fertilization takes place externally. Eggs that have not been fertilized have been caused to develop in a variety of ways; for example, by adding more salts to sea water, or by adding weak acids or by changing the temperature. This is known as artificial parthenogenesis. (See page 338.)

The Starfish (*Class Asteroidea*).—The starfish are familiar objects to people who visit the sea coast. Typically, they consist of a central disk and five radiating arms which are not distinctly set off from the disk. Occasionally, four-armed starfish are found, and one kind has nine to eleven arms, another, twelve to fifteen arms. Most of the starfish are 5 or 6 inches in diameter, but a common American form is about 1 foot in diameter. In most of our common starfish the disk is small and the arms are several times as long as the diameter of the shell, but in other forms the disk is large, often with a diameter greater than the length of the arms.

Our common starfish are placed in the genus *Asterias*. On the Atlantic Coast one species is more northern in its distribution while the other species is more southern. The genus *Luidia* contains slender, graceful starfish, whose arms are easily broken. *Astropecten articularis* is one of the most beautiful starfish with slender, pointed arms fringed with long spines. *Oreaster reticularis* is the common large starfish with thick body and short thick arms. It is often 1 foot in diameter. *Asterina*, *Hippasteria* and *Ctenodiscus* are genera with large disks and short, broad, sharply pointed arms. Some of the species of Asterina are very small, about 1 inch in diameter. The genus *Solaster* contains species with large disks and slender arms, from ten to fifteen in number.

The Brittle Stars (*Class Ophiuroidea*).—The brittle stars or sea spiders (Fig. 197) have a conspicuous central disk and slender arms which are very distinct from the disk, not merging with it as in the starfish. They are not so well known as starfishes, as they usually live at greater depths, are more active and much more difficult to capture. The arms break off readily and the animal frequently uses this method of escape. The lost member is regenerated later.

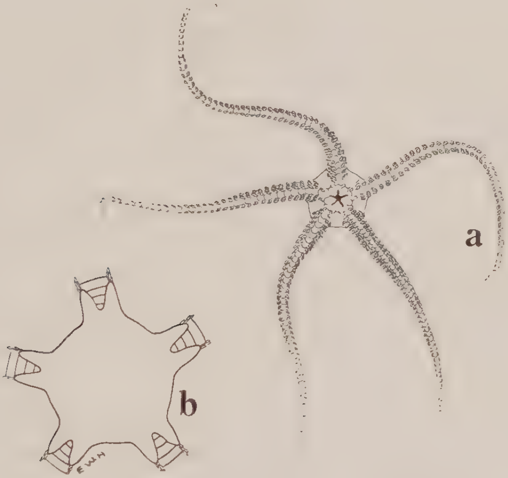


FIG. 197.—Brittle star. *Ophioderma brevispina.*

Ophiopholis aculeata is a shallow water form fairly common in the North Atlantic Ocean. *Amphipholis squamata* is our smallest species, with a disk about $\frac{1}{4}$ inch in diameter, and delicate thread-like arms. *Gorgonocephalus agassizii* is the basket star. Its arms are much branched and curved to form a somewhat basket-shaped animal.

Sea Urchins and Sand Dollars (*Class Echinoidea*).—The members of this class are spherical, hemispherical, or flattened animals with the plates firmly united to form a solid test. Some forms are so completely covered with long spines that their true shape is completely concealed. While the apparent shape of these animals is so different from that of the starfishes, the animal may be readily derived from the typical starfish shape by imagining that the arms have been bent up over the aboral surface until the tips meet, leaving only a small area of the aboral surface exposed. Now if the edges of the arms are permitted to grow together so that a solid test is formed and the animal more or less flattened, a typical sea urchin will be formed. It must not be assumed that this is the way the sea urchins have developed, but simply that this explains the arrangement of the plates and the tube feet. The plates are arranged in alternate radial and interradial areas. The radial plates have openings for the tube feet and all the plates bear movable spines and elaborate pedicellariæ which keep the surface clean. The tube feet are slender and much elongate and the animal is capable of slow movements by using the tube feet. Some species walk by using the movable spines.

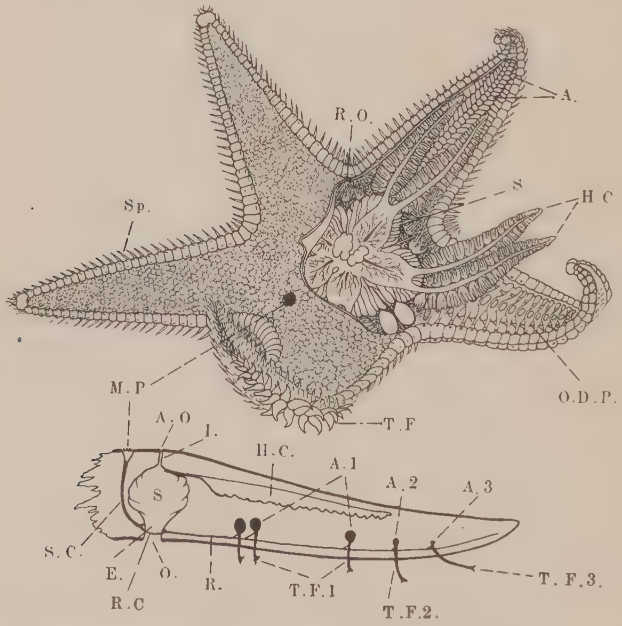


FIG. 198.—Starfish showing general external and internal anatomy and longitudinal section of arm. *A.*, Ampullæ; *A. 1.*, Ampullæ fully expanded; *A. 2.*, Ampullæ partially emptied; *A. 3.*, Ampullæ completely emptied; *A. O.*, Anal opening; *E.;* Esophagus; *H. C.;* Hepatic cæca; *I.*; Intestine; *M. P.;* Madreporite plate; *O.*, Oral opening; *O. D. P.*, Oral dermal plates; *S.*, Stomach; *S. C.*, Stone canal; *Sp.*, Spines; *R.*, Radial canal; *R. C.*, Ring canal; *R. O.*, Reproductive organ; *T. F.*, Tube feet; *T. F. 1*, Tube feet fully retracted; *T. F. 2.*, Tube feet partially extended; *T. F. 3.*, Tube feet fully extended.

The sea urchins proper (Fig. 199) are hemispherical, spiny animals, resembling large chestnut burs. They are usually more abundant on rocky than on sandy coasts and live in the cracks and crevices of the rocks or in small pockets or holes that they construct. They feed on algæ and organic débris. The oral opening is provided with an elaborate arrangement of teeth, called Aristotle's lantern. This structure and the tests denuded of spines are frequently sold as curios.

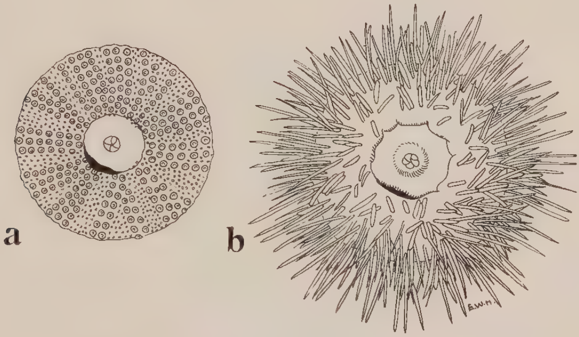


FIG. 199.—Sea urchin. *Arbacia sp.* *a*, test with spines removed, oral view; *b*, test with spines.

The sand dollars are greatly flattened echinoids with nearly circular outlines and the tube feet arranged in a star-shaped area. The surface of the body is covered with fine, short spines. The denuded tests are common among the coast and are frequently preserved as curios. These animals are important as food for many species of fish. The key-hole urchins (Fig. 200) are similar to the sand dollar, but the shell is pierced by five elongate holes.

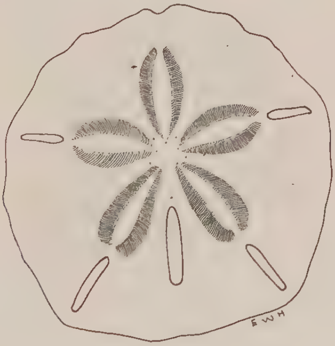


FIG. 200.—Key-hole urchin. *Mellita quinquiesperforata.*

Sea Cucumbers *(Class Holothuroidea)*.—The animals of this class are elongate sac-like organisms with a tough muscular outer coat (Fig. 201). The calcareous plates which make up the test of the other kinds of Echinoderms are reduced to minute spine-like plates. The oral end is provided with a circle of much-branched tentacles which may be withdrawn into the body. These tentacles are highly sensory and are organs of touch and smell. In species of the genus *Leptosynapta* the tube feet are wanting, and locomotion is carried on by the contractions of the muscular body. North American species are long, slender, worm-like animals living in sand at low-tide level and making definite tubes into which they retreat when the tide is out. In the genus *Psolus* the tube feet are well developed in a sole-like area. These animals attach themselves by this area and creep about on the rocks where they live. The common sea cucumber, *Cucumaria frondosa*, is abundant along the rocky New England Coast occurring in tidal pools. It is the largest of our sea cucumbers and is often more than 1 foot in length when fully extended.

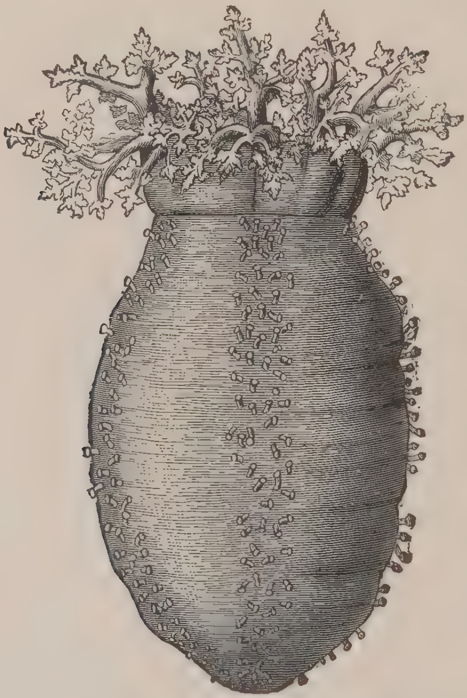


FIG. 201.—Sea cucumber. *Cucumaria frondosa.* (From Emerton.)

The Sea Lilies (*Class Crinoidea*).—The member of this class are usually attached, stalked forms (Fig. 202). The animal consists of a stalk and a calyx which is the animal proper. The mouth opening is in the center of the calyx and is surrounded by five branched arms. The sea lilies are a decadent class of animals. Fossils are abundant, especially in the early coal measures. In fact, many more fossil forms are known than living forms. Living Crinoids are found in the sea at moderate depths, a few forms occurring at great depths. The water vascular system is reduced and the tube feet are sensory organs.

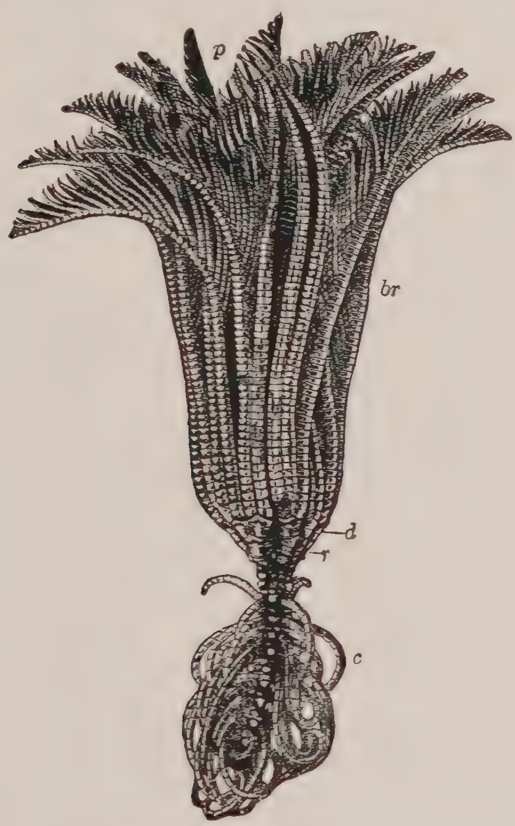


FIG. 202.—Sea lily. *Pentacrinus macleayanus.* *br*, brachialia; *c*, cirri; *d*, distichalia; *r*, radialis; *p*, pinnulæ. (After Wyville Thompson.)

ECONOMIC IMPORTANCE OF THE ECHINODERMS.

The members of this phylum are of very little economic importance. Some of the species are of importance as food for sea fishes that are used as human food and are thus indirectly of importance to man. But on the whole, these animals with their tough calcareous tests are very poor food for any animals.

A few kinds of Echinoderms are used for human food. The most important of these are the sea cucumbers whose muscular bodies, dried or smoked, are much esteemed by Oriental peoples. These animals are captured, cleaned and boiled, and then dried in the sun or over a fire. The dried bodies, which are very gelatinous, are used for soup. Extensive fisheries for the capture of these animals are maintained among the coral reefs of the Philippines, the East Indies and Australia. Some of the sea urchins, called sea eggs, are captured during the spawning season and the egg sacks used for food. The eggs or roe of the starfish are also sometimes used for food. When properly prepared by salting and smoking they are said to be delicious.

Perhaps the starfish are the echinoderms of greatest economic importance as enemies of the oyster and other edible bivalves. It is one of the most important enemies of the oyster industry. The oystermen capture the starfish by dragging mops made of frayed rope over the oyster bed. The starfish become entangled in the strands of the frayed rope and are hauled out and killed by dipping in hot water or by steaming. It is estimated that from 5000 to 10,000 bushels of starfish are captured annually in this way in Long Island Sound. Formerly the starfish were simply cut into pieces and dumped back into the sea, but it was discovered that these animals regenerated the lost parts and that the oystermen were not decreasing the supply of starfish by this method.

At first thought, it would hardly seem possible that a comparatively weak animal like the starfish could open an animal as difficult to open as an oyster. But the arms are wrapped about the bivalves and numerous tube feet are attached to each shell and then by steady pulling, the shell is forced open. The stomach of the starfish is everted and the digestive juices are poured into the shell of the oyster and the soft parts completely digested and sucked into the stomach. A single starfish is said to be capable of eating as many as two dozen in a single day. When it is recalled that starfish occur in unnumbered thousands, the real importance of these animals as pests of the oyster industry can be appreciated.

CHAPTER XII.

PHYLUM NEMATHELMINTHES.

(ROUND WORMS.)

- NEMATODA
  - Typical example
  - The vinegar eel and its relatives
  - The ascaris and its relatives
    - The ascaris of man
    - The ascaris of the horse
    - The ascaris of the chicken and pigeon
    - The pin worms
  - The hookworms and their relatives
    - The hookworm of man
      - Hookworm disease
    - The hookworms of domestic animals
    - The gape worm of chickens
    - The lung worms
  - The whip worms
  - The trichina and trichinosis
  - The filaridæ
    - Microfilaria
    - Guinea worm
- ACANTHOCEPHALA
  - The thorn-headed worms
- GORDIACEA

THE worms of this phylum are slender, thread- or hair-like worms with smooth, unsegmented bodies. Three distinct classes are usually recognized, the Nematoda, Gordiacea and Acanthocephala.

Class Nematoda.—This class includes the typical round worms (Fig. 203). The digestive tract is usually a nearly straight tube, starting with the mouth at the anterior end of the body and terminating at the anus, near the posterior end of the body. The digestive tract is frequently differentiated into a muscular buccal cavity which may be provided with papillæ or teeth, or both. The buccal cavity serves to attach parasitic worms to their host. Following the buccal cavity there is frequently a muscular pharynx which leads to the elongate intestine which narrows to the cloaca.

The sexes are separate and the sex organs are much simpler than in the flat worms. In the males there is usually a single tubular testis which leads to the vas deferens and this opens into the cloaca. The cloaca of the male is sometimes provided with copulatory spicules, sometimes with a copulatory bursa, which is often an elaborate structure composed of two wing-like membranes stretched over finger-like supports. The female organs usually consist of two, sometimes only one, coiled tubular ovaries. Anteriorly the two ovaries enlarge to form the two horns of the uterus. The two horns of the uterus unite to form a single vagina, which opens to the exterior through the genital pore. The genital pore is located on the ventral side of the body, frequently about one-third of the length of the body from the mouth, sometimes posterior to this.

Excretion is carried on through two lateral excretory canals which unite anteriorly and open to the exterior through a single excretory opening just posterior to the mouth.

Round worms exhibit a wide variety of life histories. Some forms are free-living. Others are completely parasitic, and some forms are parasitic in one stage of their life cycle, but free-living in the other. Some forms have an alternation of hosts while other forms spend their entire life cycle in a single host. Some forms are oviparous while other forms are viviparous. Many of the parasitic forms are of prime importance, especially in tropical and warm temperate regions of the globe, both as pests of man and of domestic animals. Other forms are important pests of some of our cultivated plants.

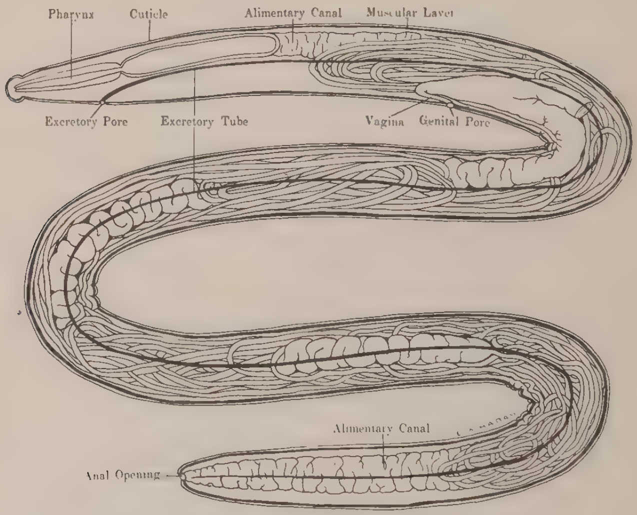


Fig. 203.—A diagram of a typical round worm.

The Free-living Nematodes.—Many nematodes are free-living, occurring abundantly in salt and fresh water, in damp earth and in decaying organic material. Many of these forms are exceedingly abundant, and some are very small, not exceeding 1 mm. in length. To this group belongs the common vinegar eel, sometimes found in vinegar where it lives on a fungus growth.

Ascaris and Its Relatives.—This group includes some of the largest of the round worms. The common ascaris or eelworm (Fig. 204) is a parasite of man and of the pig. Other species occur in the horse, the cow and the sheep. Eelworms, *Ascaris lumbricoides*, are frequently 8 to 10 inches long and $\frac{1}{4}$ inch in diameter. They live in the small intestine and the eggs pass out with the feces. These eggs may be carried to food by the house fly, by the wind or on the hands of unclean persons. If the eggs are eaten, the young worms hatch in the small intestine where they remain.

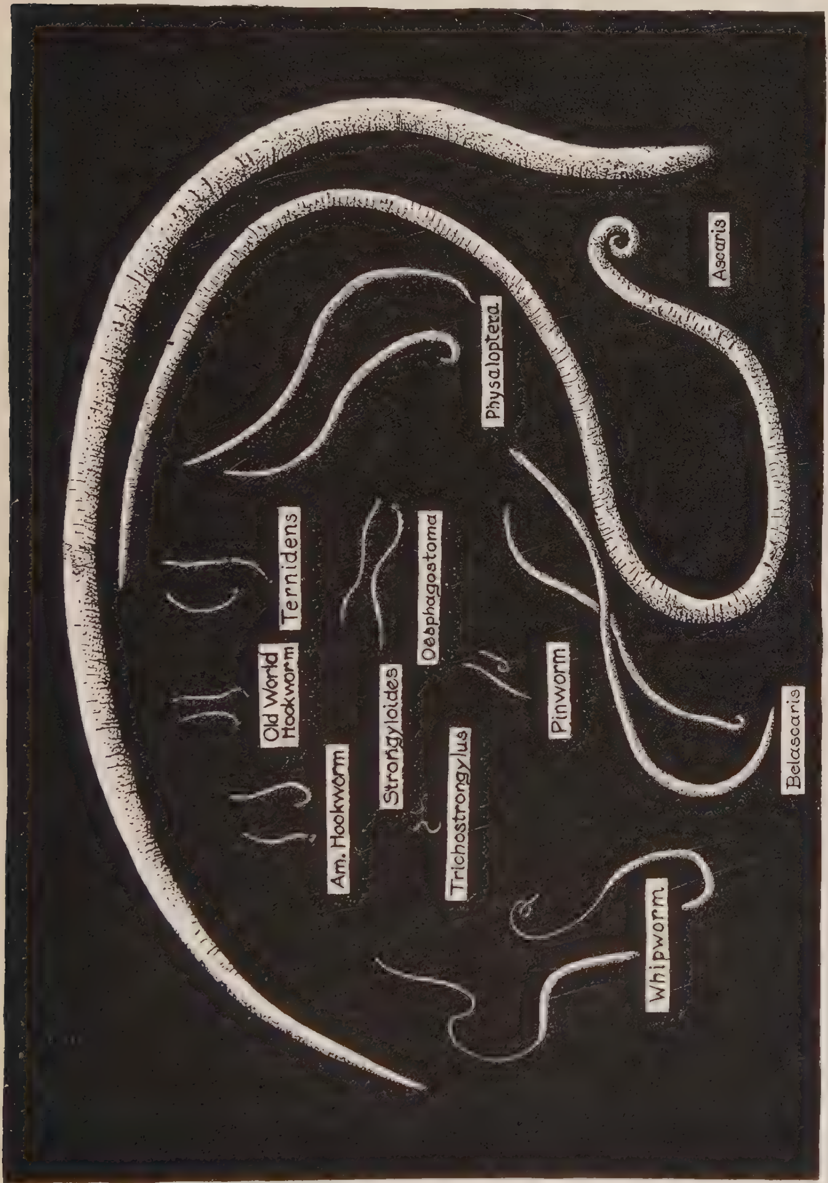

Ascaris
Physaloptera
Ternidens
Oesphagostoma
Old World Hookworm
Strongyloides
Pinworm
Belascaris
Am. Hookworm
Trichostrongylus
Whipworm

FIG. 204.—Intestinal nematodes of man, natural size. Male and female of each species shown, except *Strongyloides*, in which only the female is known. The female of *Œsophagostoma* is immature, the mature form being unknown. (From Chandler's "Animal Parasites and Human Diseases," Courtesy of John Wiley & Sons.)

It has been suggested recently that these eggs may be eaten by rats and that the eelworm may pass its larval stage in the rat.

After hatching in the digestive tract of the rat the larvæ may develop in the lungs of the rat and pass out of the mouth to food that the rat has fed upon. If these young larvæ are eaten by humans they develop into full-grown eelworms in the small intestine. The presence of a few eelworms usually causes no serious trouble, but if the eelworms become abundant they frequently cause serious nervous disorders and digestive disturbances, accompanied by anemia.

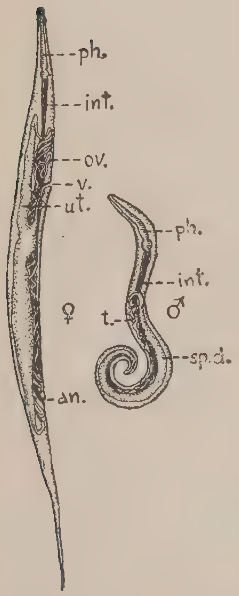
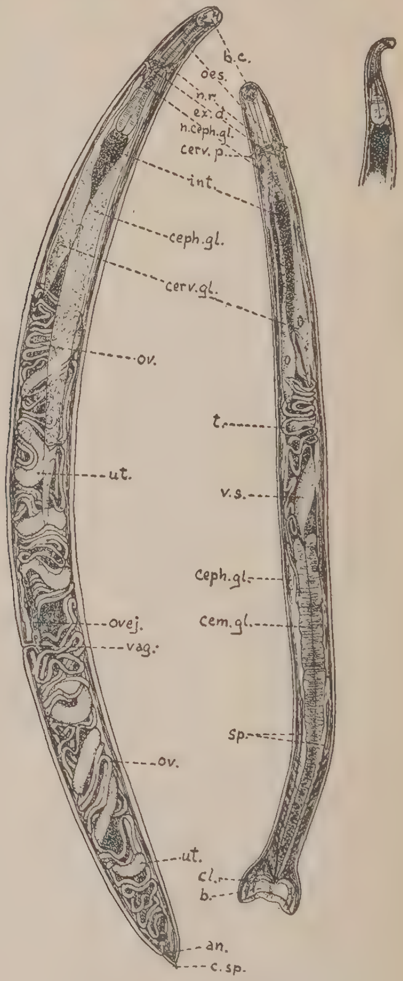

ph.
int.
ov.
v.
ut.
♀
an.
ph.
int.
t.
♂
sp.d.

Fig. 205. — Pin worm. *Oxyuris vermicularis.* Female; male; *ph.*, pharynx; *int.*, intestine; *ov.*, ovary; *ut.*, uterus; *an.*, anus; *v.*, vulva; *t.*, testis; *sp.*, *d.*, sperm duct. (From Chandler's "Animal Parasites and Human Diseases;" courtesy of John Wiley & Sons.)


b.c.
oes.
n.r.
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cerv.p.
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v.s.
ceph.gl.
cem.gl.
ovej.
vag.
sp.
ov.
ut.
cl.
b.
an.
c.sp.

Fig. 206.—American hookworm. *Necator americanus.* Male and female. (From Chandler's "Hookworm Diseases;" courtesy of Macmillan Company.)

The eelworms which occur in domestic animals are frequently very troublesome to young animals, especially colts, calves, lambs, kittens and puppies. While it is impossible to give symptoms that will apply to all animals, in general there is a great deal of intestinal catarrh and persistent diarrhea.

Smaller worms (genus *Heterakis*), usually from ½ to 3 or more inches in length, but otherwise quite similar to the larger eelworms of man and domestic animals, are found in domestic birds of various kinds. These small eelworms are sometimes excessively abundant and cause serious digestive disturbances which may lead to the death of the bird.

Pin worms, genus *Oxyurus* (Fig. 205), are small round worms which live in the intestine of various animals. One species is very abundant in children and another is frequently found in the horse. So far as is known the development is direct. The eggs may be transferred directly on the hands of infected persons to food or water. The worms in the intestine seem to do very little damage, but as they become sexually mature, they wander down to the rectum and through the anus and over the adjacent surface of the body, where they set up an intolerable itching. In the scratching that follows the eggs get on the hands and may then be transferred to the mouth or to the food and water. A similar worm is sometimes found in the horse and produces symptoms similar to those in man.

The Hookworms and Their Relatives.—This is a very large group of small, round worms which are widely distributed, especially in tropical and warm temperate regions of the globe. Hookworms, *Anchylostoma spp.* (Fig. 206), of various species are found in practically all kinds of domestic animals and in man. The male is provided with an elaborate bursa. The female is larger and the genital pore is located on the posterior third of the body. The life cycle of most species is fairly direct. The eggs falling in moist soil hatch into larvæ which gain entrance into the body of the host if it comes in contact with the soil.

There are two distinct species of hookworms of man, the American and European. They differ only in minor details of structure. In the essential details of their life histories and the diseases they cause they are the same; hence, they will be treated as one species.

The European species may have originated in the Mediterranean region and then spread to other parts of the world along the ancient trade routes. The American species originated perhaps in Africa being spread by slave trade to North and South America and to the West Indies.

If the soil becomes polluted, the full-grown larvæ of the hookworm will gain entrance wherever the bare skin comes into contact with the polluted soil. If large numbers of larvæ enter at any one point they produce a characteristic sore known locally as ground itch, miner's itch and potter's itch. The larvæ work their way to the blood vessels and are carried eventually to the lungs, where they work their way to the air passages and are coughed up and swallowed. In this round-about way the larvæ finally reach the intestine. In the intestine they develop to maturity, mate and the female lays an enormous number of eggs which pass out with the fecal matter, thus the soil may be polluted. While the majority of larvæ undoubtedly reach the intestine in this round-about way, some gain entrance into the digestive tract directly by the person drinking polluted water, by eating polluted green vegetables, by eating polluted dirt and from hands that have been in contact with polluted soil.

The symptoms of the disease are not always the same, but there is a general clinical picture that is very characteristic. The patient is anemic, with pasty white skin. Mental growth is retarded and physical strength is greatly lessened. Patients are frequently dirt eaters and the abdominal cavity is enlarged, often enormously, such patients being pot-bellied. Physical resistance is greatly lowered, so that the patient may readily succumb to any minor ailment. The retarded mental and physical development and the lowered vitality of the patients are marked and economically important characteristics of all hookworm countries. These symptoms are produced not only by the loss of blood which the hookworms devour, but by a toxic substance which the hookworms secrete and by bleeding intestinal sores produced by the hookworms.

There are a number of remedies that may be used with safety under a physician's direction to kill and expel hookworms. The stories of rapid recovery of patients are almost beyond belief. Backward, underdeveloped and mentally deficient children are changed suddenly into mentally alert, physically developed youths. In regions of the world where hookworms are prevalent, every care should be taken to prevent soil pollution by proper sewerage disposal.

Most kinds of domestic animals harbor some kinds of hookworms. They are often excessively abundant in the horse, but in this animal they cause no serious disturbances. In the dog and the cat they are often abundant and frequently very troublesome in puppies and kittens. Infected animals are dull, listless and stupid, and will not play as normal puppies and kittens do. Unless proper remedies are given, such animals become poor and emaciated and are troubled with chronic diarrhea and dysentery.

The stomach worm of the sheep is closely related to the hookworms. It causes a serious disease of sheep, especially of lambs. The characteristic symptoms are dullness, emaciation followed by black diarrhea and quite frequently by death in the course of three or four months. The eggs of these worms pass out with the fecal matter and develop into larvæ in damp soil. They may be taken up by uninfected sheep in pastures or in polluted drinking water. It is, therefore, of the greatest importance to avoid pasturing lambs in a field where old sheep have pastured.

There are two distinct types of lung worms of sheep—one that lives in the bronchial tubes and the other living in the substance of the lungs. The former is more frequently a parasite of lambs and yearlings and causes a distinct bronchitis. The latter is more frequently a parasite of older sheep and causes pneumonia. Frequently, however, both kinds of worms occur in the same animal. The characteristic symptoms of this disease are a convulsive cough which frequently becomes violent enough to prostrate the animal, and a mucus discharge from the nostrils which contains large numbers of the eggs and larvæ. Infection is believed to be direct and infected animals should be isolated.

Similar lung worms are sometimes present in pigs, calves, kittens and young rabbits. They cause characteristic coughing fits. Such infected animals loose flesh and frequently die.

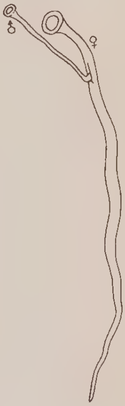

Fig. 207.—Gape worm. *Syngamus trachealis.*

The gape worm of the chicken, *Syngamus trachealis* (Fig. 207), is a very troublesome pest of young chicks, living in the trachea and producing a characteristic disease known as gapes. The symptoms of this disease are a peculiar gasping, wheezing cough, accompanied by a stretching of the neck. The worms are peculiar in that the males are permanently attached to the females, producing a Y-shaped figure, and hence frequently called the forked worm. These parasites are often fatal, not only to chicks, but also to young turkeys and young pheasants.

It is believed that infection may be direct by birds picking up discharged adult worms full of eggs. It has also been suggested that the larvæ develop in earth worms and that birds become infected by eating the earth worms. The rapidity with which infection runs through a flock would seem to suggest that direct infection was the usual method.

As in the case of other parasites, overcrowding of young birds is to be avoided. Neither should young birds be confined to runs with old birds. Infected chicks should be isolated and fumigated with burning sulphur or tobacco fumes. The soil-infected runs should be treated with salicylic acid or sulphuric acid diluted at the rate of 1 part to 1000 of water. The common practice of attempting to remove the worms with a feather should be avoided because of the danger of strangulation.

Whip Worms.—Whip worms belong to the genera *Trichuris*, *Trichocephalus* and *Trichosomum*. They are characteristic, elongate round worms with the anterior part of the body slender and thread-like and the posterior part of the body enlarged. Whip worms of various species are common parasites of man and various domestic animals, such as the cow, sheep, pig, dog and cat, and of domestic birds, like the chicken, pheasant, duck and goose. While these worms may often be excessively abundant and difficult to dislodge, they seem to cause no really serious diseases, unless they are a contributing cause to appendicitis in man.

Trichina.—The trichina, *Trichinella spiralis* (Figs. 208 and 209), is one of the most dreaded of the parasitic diseases of man. This dread is not without foundation, for the disease is often fatal to man, frequently causing the death of from 25 to 30 per cent of those infected.

This is a parasite of various mammals, such as man, pig, rat, cat and dog. Man becomes infected by eating improperly cooked pork. The other animals undoubtedly become infected

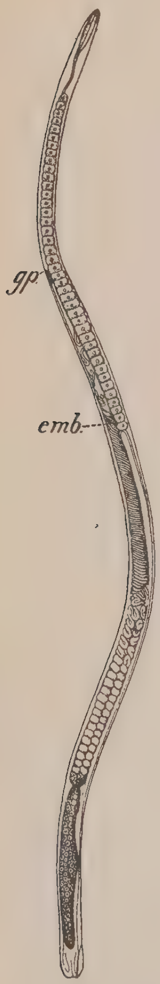

Fig. 208.—*Trichinella spiralis.* Adult female, showing embryos, *emb*, in uterus; *gp*, genital opening through which the embryos are discharged. Enlarged. (After Leuckart, U. S. Bureau of Zoölogy, Department of Agriculture.)

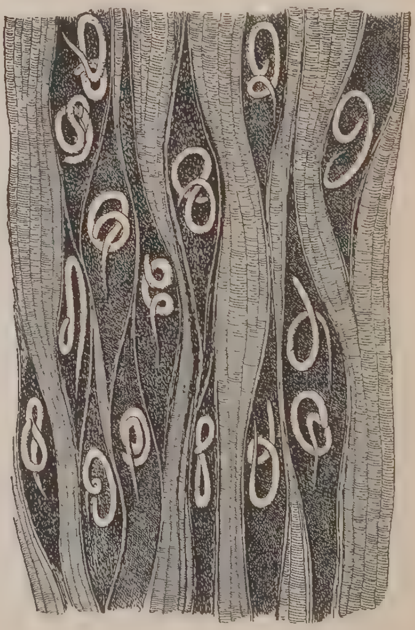

Fig. 209.—Larvæ of *Trichinella spiralis* in a muscle, not yet encysted. Enlarged. (After Leuckart, U. S. Bureau of Zoölogy, Department of Agriculture.)

by eating trimmings from pork or by eating rats which may have become infected by eating infected rats. When an animal eats the flesh of another animal containing the encysted larvæ of the trichina the cyst dissolves in the small intestine and the larvæ which are released become mature. The mature worms mate and the females retain the eggs until the larvæ hatch. The larvæ then pass into the circulatory system and are carried to the muscles where they encyst. A single larva may form a cyst around itself or several larvæ may be enclosed in a single cyst. Unless the host in which they have encysted is eaten by another host the larvæ do not develop further. But if they are eaten, the cyst dissolves and the cycle is repeated.

Perhaps the most characteristic symptom of the disease is rheumatic pains caused by the larvæ entering the muscles in untold thousands and encysting. The best method of avoiding the disease is not to eat pork unless it has been thoroughly cooked.

Trichinosis is not usually prevalent except among Germanic peoples who have the habit of eating uncooked or smoked sausages. Holding pork in cold storage at a low temperature for a couple of weeks is said to be fatal to encysted trichina.

The Filaridæ.—The Filaridæ are very long, slender, round worms. There are two distinct types which are parasites of humans, the so-called microfilaria or blood filaria and the guinea worm.

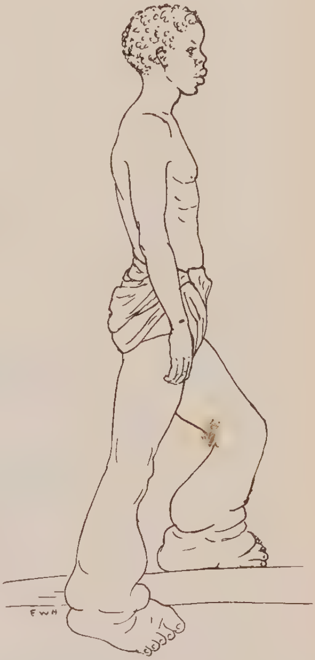

Fig. 210.—Effects of elephantiasis.

The microfilaria which occur in the blood are the larvæ of round worms which live in the lymphatic vessels. The larvæ enter the blood stream, where they swarm at night. If the larvæ are swallowed by a mosquito which has bitten an infected person, they escape from the stomach and become full grown in the muscles of the mosquito and migrate to the proboscis. If such a mosquito bites a human the larvæ enter the blood stream and the person becomes infected. The microfilaria cause the disease known as elephantiasis (Fig. 210). The characteristic symptoms of this disease is an enormous enlargement of the parts, especially the feet, lower limbs and scrotum. This disease is confined to the warm zone of the world.

Class Acanthocephala.—These worms are usually known as thorn-headed worms (Fig. 211) because they are provided with a distinct proboscis which is thickly set with recurved hooks. They parasitize various animals, being especially common in fishes, ducks, geese and pigs. The species that parasitizes the ducks and geese is said to develop as a larva in one of the small crustacea (Gammarus) found in fresh water. The thorn-headed worm of the pig is often abundant in the small intestine and is especially troublesome to young pigs, as it sets up serious digestive disturbances which cause convulsions and spasms and sometimes death. The proboscis may penetrate the intestine, causing definite lesions. The eggs passing out with the fecal matter may be eaten by the white grubs which are the larvæ of the May beetle. The white grubs live on the roots of grasses and are usually abundant in sodlands. Pigs root up the sod and devour the white grubs containing the larval thorn-headed worms. The larvæ attach themselves to the walls of the small intestine of the pig and develop to maturity.

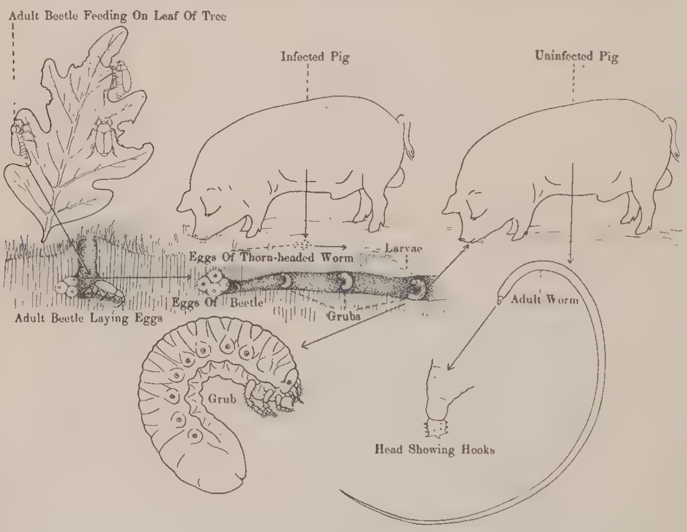

Fig. 211.—Diagram of the life history of the thorn-headed worm of pigs.

Class Gordiacea.—These are long, slender, round worms usually called horse-hair snakes. This name arose from the occurrence of these worms in watering troughs and in springs and other places where domestic animals drink, the popular supposition being that the coarse hair from the mane or tail of a horse develops into a horse-hair snake. These worms are parasites in the bodies of grasshoppers, crickets and other insects. Not infrequently these worms are found on cabbages or other green vegetables. Such worms are called cabbage snakes and are popularly supposed to be dangerously poisonous. Cabbage containing cabbage snakes is usually thrown away, but it is, of course, absolutely harmless.

CHAPTER XIII.

THE FLAT WORMS AND SOME IMPORTANT ANIMAL PARASITES.

(Phylum Platyhelminthes.)

- Tremotoda
  - Typical examples
  - Typical life history
  - Liver flukes
    - Sheep
    - Cattle
    - Cat, dog and man
  - Intestinal flukes
    - Man
    - Cattle
  - Lung flukes
    - Man
    - Pig
  - Blood flukes
- Cestoda
  - Typical examples
  - Typical life history
  - Tapeworms of man
  - Tapeworms of cat and dog
  - Tapeworms of other domestic animals
  - Tapeworms of domestic fowls

The animals belonging to this phylum are "flat worms." All of them may be distinguished by the fact that their bodies are much flattened, often very thin and broad. The phylum is composed of three distinct classes, the Turbellaria, Trematoda and Cestoda.

The *Turbellaria* are mostly free-living forms found in fresh and marine waters or in damp earth. A few are parasitic on marine animals, such as the king crab and sea snails. The members of this class have been much used for laboratory study, especially for the study of regeneration. Outside of this they are of little importance and will not be discussed further.

The *Trematoda* are usually called flukes. They are parasitic on man and various animals, and their presence often causes serious disturbances or diseases of man and his domestic animals. The life histories of some forms are simple and direct, but in other forms two or three hosts may be involved and the life history may be very complicated.

The *Cestoda* are known as tapeworms. They are also parasites and their life histories are often complicated.

THE TREMATODA.

The sheep liver-fluke (Fig. 212) is usually taken as an example of this class, as it is one of the commonest and best-known examples. It is a very flat worm, about 1 inch long and ½ inch wide. It resembles a small, thick leaf, with a small, pointed lobe at the apex. On the apex of this lobe is situated the oral sucker, and slightly posterior to the base of the lobe there is another sucker known as the ventral sucker.

The adult may be considered as a small but efficient egg-laying organism. It has been estimated that one fluke may lay as many as 500,000 eggs during its life time. The chances of an egg producing an adult is rather remote, as will be seen from a study of the life history. Therefore, this great number of eggs is essential for the perpetuation of the species. In such an organism the reproductive functions are very important, and the reproductive system is very complex. This system is further complicated because the organs for both sexes are contained in the same individual.

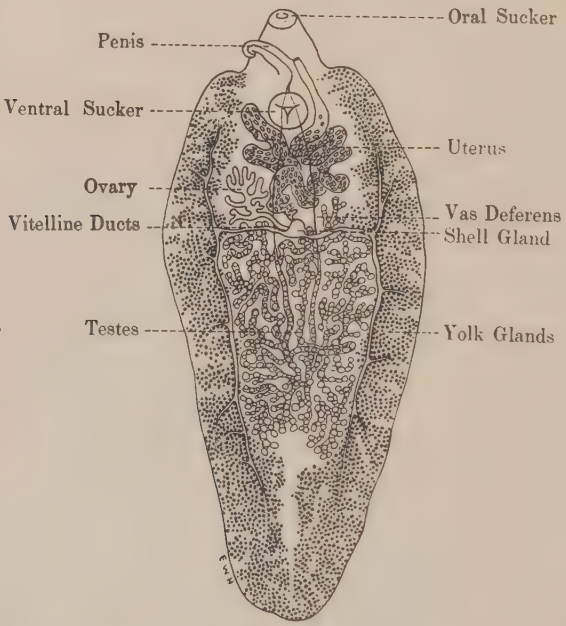

Fig. 212.—The reproductive system of the liver fluke of the sheep.

The *male organs* consist of a pair of much-branched *testes*, which occupy the great central area of the body, where the sperms are formed. From each testis a slender duct, the *vas deferens*, leads forward to the region just anterior to the ventral sucker, where they unite to form a sac-like *seminal vesicle*, in which the sperms are stored and which leads to the *ejaculatory duct* of the male and thence to the copulatory organ or *penis*.

The *female organs* consist of a single much-branched *ovary*, lying just posterior to the ventral sucker. Here the ova are formed and are carried to the *shell gland* through the *oviduct*. The shell gland lies in the median line posterior to the ventral sucker. It receives not only the ova from the ovary, but the sperms which have entered through the uterus and the yolk from the yolk glands. After the sperm fertilizes the ova the yolk is deposited and the fertilized egg is enclosed in a hard, horny shell secreted by the shell gland. The egg is then passed down the much-coiled *uterus* and thence to the exterior.

In the liver fluke the other functions are subordinate to the reproductive function, and the other systems are much simpler. The *digestive system* (Fig. 213) begins with an oral opening at the bottom of the oral sucker. The oral opening leads to the muscular pharynx. The pharynx leads to the *esophagus*, which soon divides into two blind *alimentary canals*, composed of many branches that reach and carry food to all parts of the body. The food consists of the blood of the sheep which the fluke sucks from the sheep's liver. The *nervous system* consists of a pair of ganglia in the region of the oral sucker and of a pair of nerves. The *excretory system* consists of a much-branched tube which collects wastes from all parts of the body and ejects them through the excretory pore at the posterior end of the body.

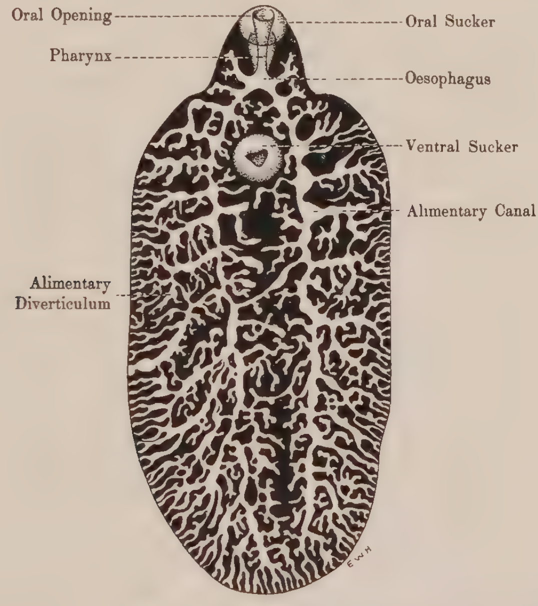

FIG. 213.—The digestive system of the liver fluke of the sheep.

A Typical Life History. –The life history of the sheep liver fluke (Fig. 214) is better known than most flukes, hence it will be repeated here. The *eggs* pass out of the uterus of the fluke into the bile duct of the sheep, thence to the intestine, and are expelled with the feces.

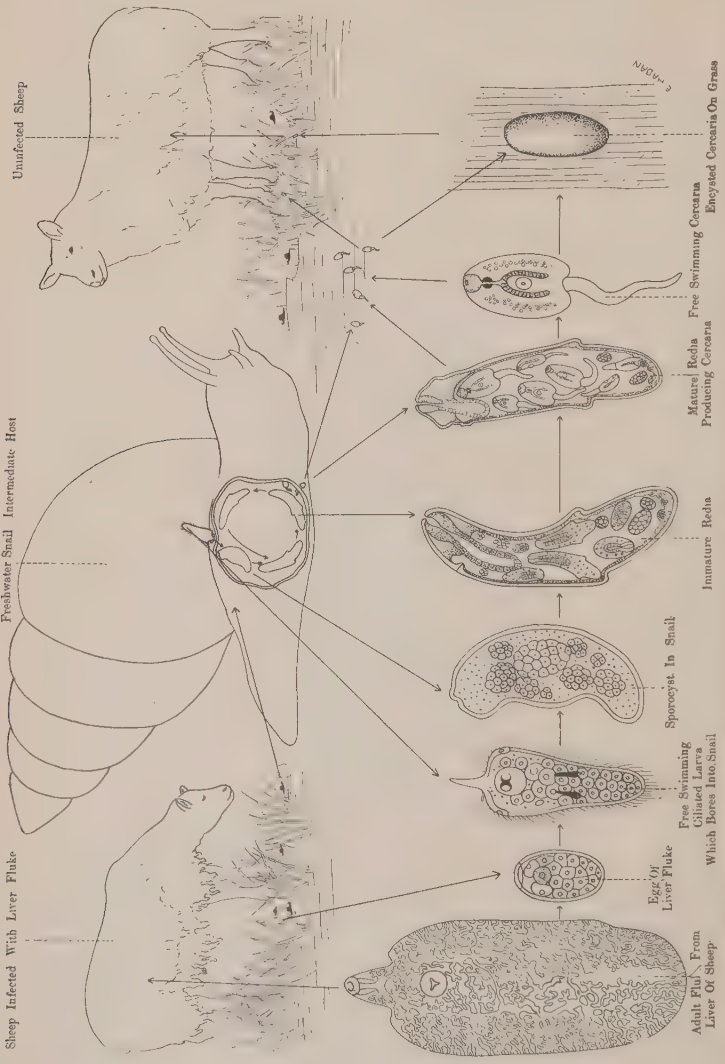
Sheep Infected With Liver Fluke
Freshwater Snail Intermediate Host
Uninfected Sheep
Adult Fluke From Liver Of Sheep
Egg Of Liver Fluke
Free Swimming Ciliated Larva Which Bores Into Snail
Sporocyst In Snail
Immature Redia
Mature Redia Producing Cercaria
Free Swimming Cercaria
Encysted Cercaria On Grass

FIG. 214.- Life history diagram of the sheep liver fluke, showing relations of primary and intermediate hosts.

If these eggs fall into water, they hatch into *ciliated larvæ* which are provided with a sharp-pointed anterior end. These larvæ swim about in the water, and if one comes in contact with a snail it will bore its way into the soft parts of the snail. Here the larva feeds and changes to a sack-like organism, called a *sporocyst*. Inside the sporocyst, by a process of asexual reproduction or internal budding, are formed rediæ. The *rediæ* are elongate, cylindric organisms with simple digestive tracts which feed upon the soft parts of the snail. The redia gives rise to other rediæ by asexual methods, and these may give rise to daughter rediæ. Eventually the rediæ still by asexual methods will produce tadpole-shaped *cercariæ*. The cercariæ then abandon the snail and swim out into the water. If a cercaria comes into contact with an object, such as a blade of grass, it encysts. If the grass containing the encysted form is eaten by a sheep, the young fluke escapes and finds its way up the bile duct.

Liver Flukes.—The liver fluke of sheep produces a characteristic disease known as liver rot. In this disease the animals become weak, anemic and emaciated and frequently die within six months. The liver becomes enlarged and adhesions develop between it and other organs. The liver first becomes soft, with numerous spaces containing young flukes. Later the tissue of the liver becomes more spongy with larger cavities and is firm and gritty. The bile ducts are filled with blood, bile and pus, causing congestion of this organ which frequently results in death. Since we know the life history of this organism, the treatment of the disease is obvious, and consists of avoiding low, wet pastures. Salt is said to be fatal to the young flukes and cercariæ and should be freely accessible to sheep on pasture. The sheep-liver fluke is primarily a pest of sheep, but has been found in most of the other domestic animals, such as the horse, pig, cow, ass, camel and rabbit.

In the southern United States there is a somewhat larger fluke which attacks the liver of cattle, but it does not seem to be very prevalent or troublesome.

In Europe there is a species of liver fluke that occurs in the cat and dog and occasionally in man. In the Orient there is another species that has the same hosts. In the United States there is still another species which is quite common in dogs and cats. The life histories of none of these species have been worked out completely. But it is believed that the rediæ live in snails, that the cercariæ become encysted in fish, and when these fish are eaten raw or smoked the young flukes emerge from the cyst and enter the bile duct. The symptoms of the disease in man are quite similar to those of the sheep. The patient becomes anemic and emaciated. The liver becomes enlarged. The bile ducts become enlarged and filled with blood, pus and bile. This leads to bloody diarrhea and quite frequently the patient succumbs.

Intestinal Flukes.—Intestinal flukes occur in a long list of animals. They are especially common in ducks and geese and occasionally occur in man. The flukes that occur in birds are about $\frac{1}{2}$ inch long, and have the body divided into two distinct regions. The anterior region is provided with numerous short spines. Many different species of flukes have been found in the intestines of man, but they are not especially important.

Lung Flukes.—In the Orient there is a serious disease of the lungs of man resembling consumption in general symptoms. This disease is caused by a small fluke (Fig. 215), about $\frac{1}{4}$ inch long. This fluke bores its way through the tissues of the lungs, often causing large cavities. The eggs are laid in these cavities and are carried up the respiratory passages and spit out. The life history is not known completely, but the rediæ stages are passed in a snail. The cercariæ encyst on a crab which is much used for food in these countries. If the encysted cercariæ are eaten, they gain entrance into the lungs. Similar species are parasites in the lungs of the cat, dog and pig and causes a similar disease in these animals.

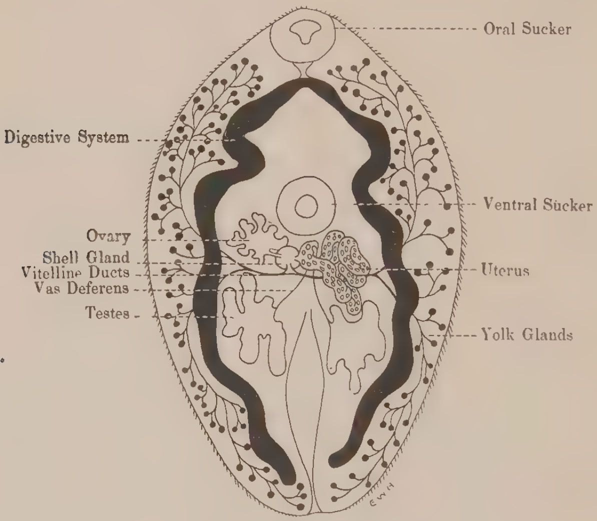

FIG. 215.—Lung fluke.

Blood Flukes.—The blood flukes (Fig. 216) which occur in man and in the cow and sheep are peculiar in a number of ways. The sexes are separate. The male is broad and flat, with the margins reflexed, forming a groove in which the slender female lies. The adult worms live in the abdominal veins of their host and apparently cause no serious disturbance. However, when the eggs are laid the eggs pass from the blood vessels, and in one species are voided with the urine and in another species with the feces. It is the migration of these eggs through the tissues, and the fact that they may lodge in large numbers in vital organs, that produce the serious disturbances characteristic of the presence of blood flukes. The life histories of these flukes, so far as they have been worked out, are quite similar in general outline to those of the liver flukes. The rediæ

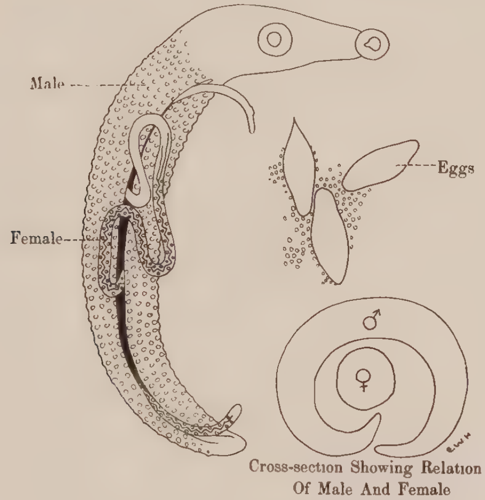
Male
Female
Eggs
♂
♀
Cross-section Showing Relation Of Male And Female

Fig. 216.—Blood fluke. (Redrawn from Manson.)

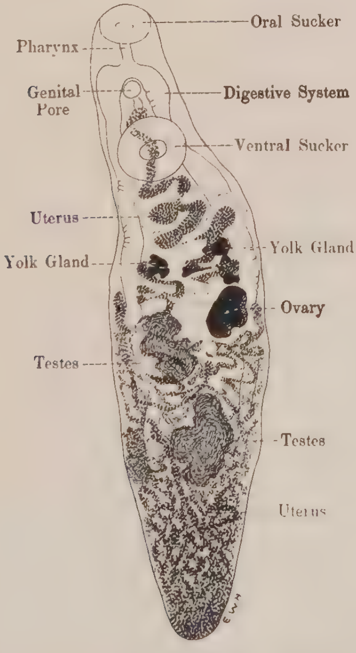
Oral Sucker
Pharynx
Genital Pore
Digestive System
Ventral Sucker
Uterus
Yolk Gland
Yolk Gland
Ovary
Testes
Testes
Uterus

Fig. 217.—Fluke from the urinary bladder of frog

A TABLE OF THE LIFE HISTORIES OF COMMON FLUKES.

Common name.	Scientific name.	Primary host.	Organs.	Rediæ in.	Cercaria.	Remarks.
Liver fluke of sheep	Fasciola hepatica	Sheep, cattle, man	Liver, lungs	Snail Lymnæa	On grass	Causes liver rot of sheep. Common in Europe and southern United States.
Large fluke of cattle	Fasciola magna	Cattle, sheep	Liver	?	?	Common in southwestern United States.
Liver fluke of dog	Opisthorchis felineus	Dog, cat, man	Liver	?	?	European.
Chinese fluke	Clonorchis sinensis	Cat, dog, hog, man	Liver	?	?	Oriental countries.
Lung fluke	Paragonimus westermanii	Man, dog, cat	Lungs	Snail	Edible crabs	Oriental countries, common.
Lung fluke of pig	Paragonimus kellicotti	Pig	Lungs	?	?	Some parasitologists believe that this is the same species as P. westermanii.
Intestinal fluke of birds	Echinostoma echinatum	Goose, duck, swan	Small intestine	Snail	In water	
Blood flukes of man	Schistosomum spp.	Man	Abdominal veins	Snail	?	Principally in Egypt.
Intestinal flukes of man	Fasciolopsis buski	Man	Intestine	?	?	Oriental region.

have been found in snails. The cercariæ have forked tails. They may be swallowed while drinking infested water or they may gain entrance directly through the skin, if a person bathes in an infested pool.

All the flukes discussed above are parasites of the higher vertebrates, birds and mammals, including man. All belong to the single family, *Distomatidæ*, which includes the flukes with two suckers, one anterior and the other ventral. In addition to these parasites of the birds and mammals, there are a number of parasites of the lower vertebrates, fishes, amphibians (Fig. 217) and reptiles. These forms belong principally to the families, Tristomidæ and Polystomidæ. The *Tristomidæ* have a pair of anterior suckers and a single posterior sucker. They are chiefly parasites on the gills of fishes. The *Polystomidæ* have a number of posterior suckers with the anterior sucker present or absent. The various species are found in the urinary bladder of the turtle, on the gills of aquatic amphibians, on the gills of fishes, etc.

THE CESTODA.

The Cestoda are known commonly as tapeworms. This name is given to these worms because of their elongate, flattened bodies, with sides nearly parallel. In addition, their bodies are divided into units corresponding to the units found in a tape measure. A typical tapeworm has three regions to its body, a head or scolex, a neck or undifferentiated region and a body composed of a number of proglottids, joined together end to end.

The *head* (Fig. 218) is the region of the body which attaches the tapeworm to its host. It is provided with suckers, usually four in number, sometimes only two or one. In addition, the heads of many species are provided with a distinct prolongation, the *rostellum*, with a circle of recurved hooks. The neck is narrower than the head and is without evident divisions. The anterior part of the body is narrow and is composed of *immature proglottids*. The proglottids increase in both length and width posteriorly. There is also a corresponding increase in development of the sexual organs of each succeeding proglottid from *immature* to *mature* and finally to *ripe proglottids* at the posterior end of the body. New proglottids are being formed constantly at the neck region and ripe proglottids are being broken off at the posterior end.

The parasitic habits of these worms is correlated with the reduction of certain organs and systems of organs. The *digestive system* is wanting, as food is absorbed directly through the body wall. The *nervous system* is reduced to a pair of longitudinal nerve cords along each side of the body. Sense organs are much reduced or wanting. There is a corresponding increase in the sex organs. Each proglottid may be considered as a unit, having a complete set of organs of both sexes when mature. The mature proglottids are all but filled with sex organs.

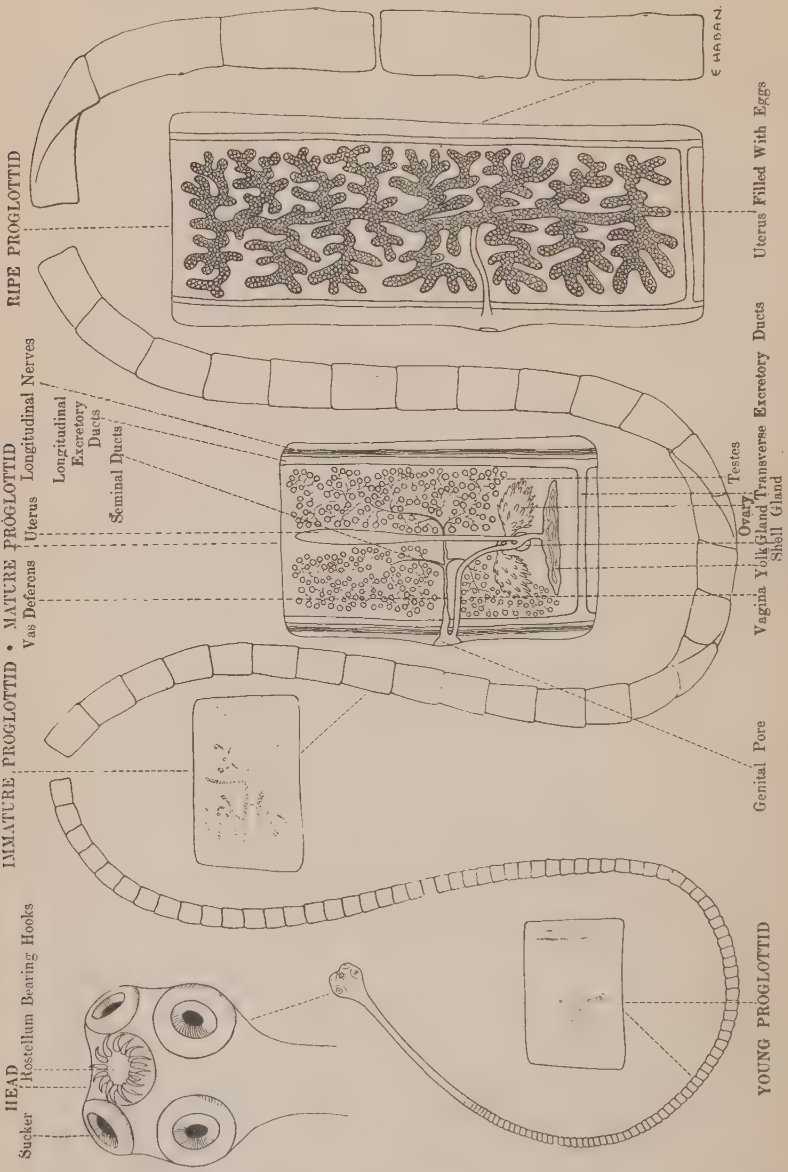
E HABAN
RIPE PROGLOTTID
Uterus Filled With Eggs
Longitudinal Nerves
Longitudinal Excretory Ducts
Seminal Ducts
Uterus
MATURE PROGLOTTID
Vas Deferens
Testes
Transverse Excretory Ducts
Ovary
Yolk Gland
Shell Gland
Vagina
IMMATURE PROGLOTTID
Genital Pore
HEAD
Rostellum Bearing Hooks
Sucker
YOUNG PROGLOTTID

FIG. 218.—Anatomy of the pork tapeworm of man.

The male organs consist of scattered granular *testes* united by *sperm ducts* which empty into the single-coiled *vas deferens* through which the sperms are conducted to the *genital pore.* The female organs consist of a pair of *ovaries* located near the posterior end of the proglottid. The ovaries are connected to the *shell gland* by a pair of *oviducts.* The *yolk gland* which lies along the posterior margin of the proglottid is also connected to the shell gland through the *yolk duct.* The *vagina* leads from the *genital pore* to the shell gland and is the passage way for the sperms from the genital pore to the ova in the shell glands. After the ova are fertilized and the yolk from the yolk gland is deposited in them the shell glands secrete a shell for their protection, and they are passed on to the uterus, which is a median, unbranched structure in the mature proglottid. In the ripe proglottid, however, it is a much-branched structure and almost fills the proglottid. The ripe proglottids may be considered as egg sacks filled with eggs.

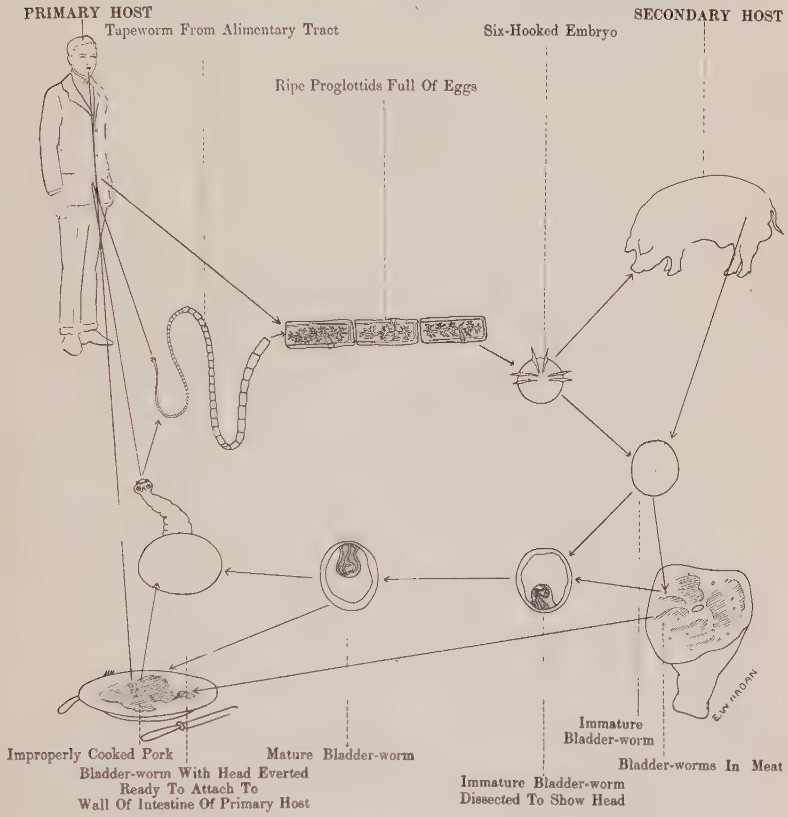
PRIMARY HOST
Tapeworm From Alimentary Tract
Six-Hooked Embryo
SECONDARY HOST
Ripe Proglottids Full Of Eggs
Immature Bladder-worm
Improperly Cooked Pork
Mature Bladder-worm
Bladder-worms In Meat
Bladder-worm With Head Everted Ready To Attach To Wall Of Intestine Of Primary Host
Immature Bladder-worm Dissected To Show Head

FIG. 219.—Life cycle of the pork tapeworm of man.

Typical Life History.—The life history of the pork tapeworm (Fig. 219) of man may be cited as a typical example. *Ripe pro-*

glottids full of eggs pass out with the fecal matter. If these eggs are eaten by a pig they develop in the pig's digestive tract into peculiar *six-hooked embryos* which are carried to the muscles of the pig. Here they develop into *bladder worms* or *cysticerci.* Each cysticercus develops a head with suckers and hooks. Now if a man eats pork that has not been cooked long enough, and which contains the bladder worms the head is everted and becomes attached to the intestine and the bladder sloughs off. The worm grows and new proglottids are formed in the neck region and a new tapeworm develops.

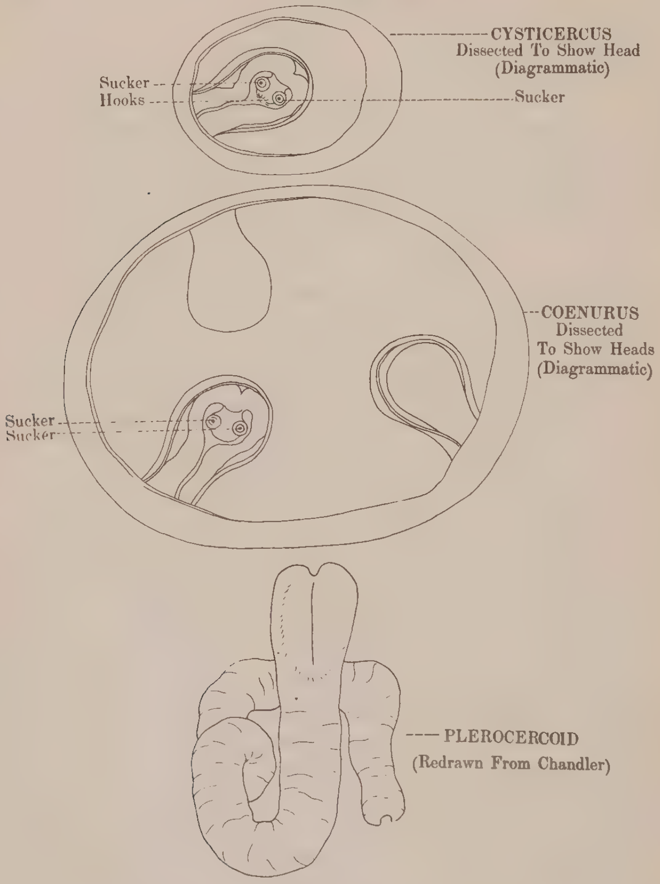
Sucker
Hooks
CYSTICERCUS
Dissected To Show Head
(Diagrammatic)
Sucker
Sucker
Sucker
COENURUS
Dissected
To Show Heads
(Diagrammatic)
PLEROCERCOID
(Redrawn From Chandler)

Fig. 220.—Diagram of types of tapeworm cysts.

The life histories of the other tapeworms are essentially like that of the pork tapeworm of man. There is, however, considerable variation in the types of larval worms. The more common type is known as the bladder worm or *cysticercus* (Fig. 220). In this type is a single head invaginated in a relatively large bladder-like structure. In the *cysticercoid* type the bladder part is greatly reduced and the larva is essentially an invaginated head without a bladder. The *plerocercoid* type of larvæ also has a single invaginated head, but the bladder portion is drawn out into a long worm-like structure. There are two general types of multiple-headed larvæ or bladder worms. In the one type each bladder contains a number of heads; this is known as a *cœnurus*. In the other type, known as the *hydatid* (Fig. 221), each bladder forms a number of cysts, each being provided with a number of heads. It is interesting to note that both types of multiple-headed bladder worms produce serious diseases.

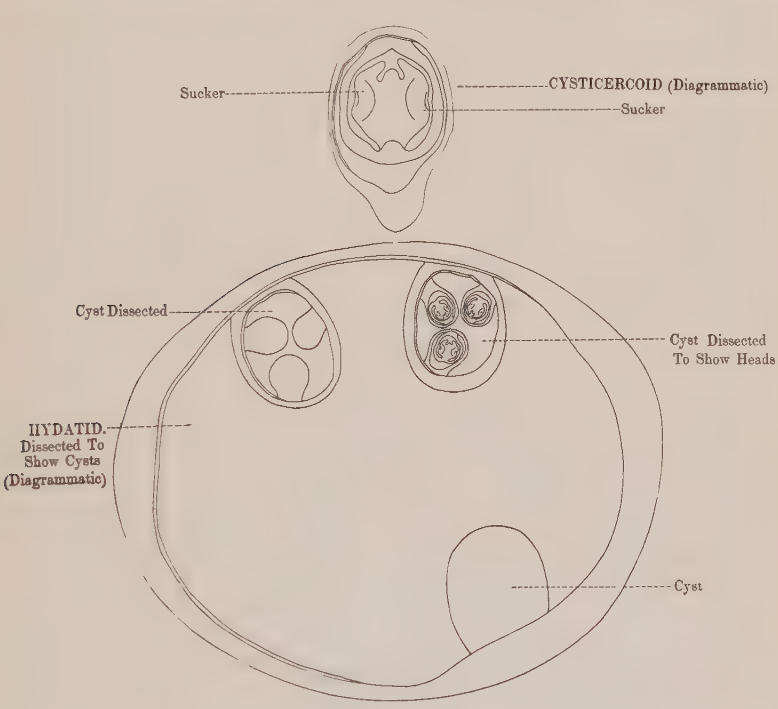
Sucker
CYSTICERCOID (Diagrammatic)
Sucker
Cyst Dissected
Cyst Dissected To Show Heads
HYDATID. Dissected To Show Cysts (Diagrammatic)
Cyst

FIG. 221.—Diagram of types of tapeworm cysts.

The following table will show the relationship between primary and secondary hosts in the common tapeworms of man and domestic animals and something of the life history relations.

Tapeworms of Man.—It will be noted from the table that man is rather commonly infected with two large tapeworms that are primary parasites of man alone. It will also be noted that the intermediate hosts are the two animals that furnish the bulk of the meat

TABLE OF COMMON TAPEWORMS (CESTODES) OF MAN AND DOMESTIC ANIMALS.

Common name.	Scientific name.	Size.	Primary host.	Organs.	Intermediate host.	Organs.	Type of larval worms.	Distribution.
Family Tæniidæ—Scolex with four suckers with or without hooks								
Pork tapeworm	Tænia solium	7–10 ft.	Man	Intestine	Hog, man	Muscles	Cysticercus	Cosmopolitan, rather rare in United States
Beef tapeworm	Tænia saginata	10–30 ft.	Man	Intestine	Cow	Muscles	Cysticercus	Cosmopolitan, fairly common in United States.
Serrated tapeworm of dog	Tænia serrata	1–3 ft.	Dog	Intestine	Rabbit	Peritoneum	Cysticercus	Cosmopolitan.
Margined tapeworm of dog	Tænia marginata	3–5 ft.	Dog, wolf	Intestine	Ruminants	Peritoneum, pericardium	Cysticercus	Cosmopolitan.
Cat tapeworm	Tænia crassicollis	1–2 ft.	Cat	Intestine	Mouse, rat	Liver	Cysticercus	Very common in the United States.
Gid worm	Multiceps multiceps	1–3 ft.	Dog, fox	Intestine	Sheep, cow	Brain	Cœnurus	Europe, United States
Hydatid worm	Echinococcus granulosus	1/10–1/15 in.	Dog, cat, wolf	Intestine	Cow, man, sheep, pig	Liver, lungs, kidneys, etc.	Hydatid	Iceland, Europe, Australia, United States.
Family Dipylidiidæ—Scolex usually with hooks								
Common tapeworm of dog	Dipylidium caninum	$\frac{1}{2}$–1 ft.	Dog, cat, man	Intestine	Cat and dog flea, dog louse	?	Cysticercoid	Cosmopolitan.
Tapeworm of duck and geese	Drepanidotænia spp.	8–10 in.	Duck, goose	Intestine	Water fleas	?	Cysticercoid	Cosmopolitan.

Tapeworm of chicken	Davainea proglottina	1/50 in.	Chicken	Intestine	Slug	?	Cysticercoid	
Tapeworm of chicken	Amœbotænia sphenoides	1/5 in.	Chicken	Intestine	Earth worm	?	Cysticercoid	Europe, South America.
Dwarf tapeworm	Hymenolepis nana	$\frac{1}{2}$–1 in.	Man, cat mouse	Intestine	Infection direct	Intestinal villi	Cysticercoid	Warm parts of World Common in southern United States.
Small tapeworm	Hymenolepis diminuta	4–24 in.	Rat, cat, mouse, man	Intestine	Meal worm	?	Cysticercoid	Cosmopolitan.
Small tapeworm of chicken	Hymenolepis carioca	3–4 in.	Chicken	Intestine	....	....	....	Common in the United States.
Subfamily Anoplocephalinæ—Scolex without hooks but with large suckers								
Tapeworm of sheep	Moniezia expensa	12–15 ft.	Sheep, cattle	Intestine	?	?	?	Central Europe, United States.
Broad tapeworm of sheep	Moniezia planissima	6 ft.	Sheep	Intestine	?	?	?	United States.
Tapeworm of horse	Anoplocephala perfoliata	3–4 in.	Horse	Intestine	....	....	....	United States.
Fringed tapeworm	Thysanosoma actinoides	10–12 in.	Sheep	Intestine	....	....	....	Western United States.
Family Bothriocephalidæ with two deep slit-like suckers								
Fish tapeworm	Dibothriocephalus latus	30–35 ft.	Man, cat, dog	Intestine	Fish	Muscles	Plerocercoid	Baltic countries southern Europe, Japan, northern United States.

that is consumed by man. In addition to these two, he harbors other tapeworms that are also found in other animals, especially the dog and the cat. The intimate relations existing between these two pets and man has also induced an intimate relation between their parasites and man.

Tapeworms are not only loathsome parasites, but it is commonly accepted at the present time that they are injurious to children, especially when they occur in numbers. The damage that they cause consists not only in the food they devour, but also of toxic substances given off by the worms which produce a variety of symptoms in different individuals, such as severe colicky pains and nervous disturbances, varying from dizziness to fits.

Perhaps more important than the presence of the worms is the presence of the hydatid of the hydatid tapeworm of the dog. The hydatid is a bladder filled with a poisonous liquid and with cysts containing the heads of the larvæ of this species. Hydatids may attack various internal organs, especially the liver. The organs attacked grow enormously in size. The hydatids are frequently several inches in diameter and there is danger that these sac-like structures will break, thus pouring the poisonous liquid into the blood.

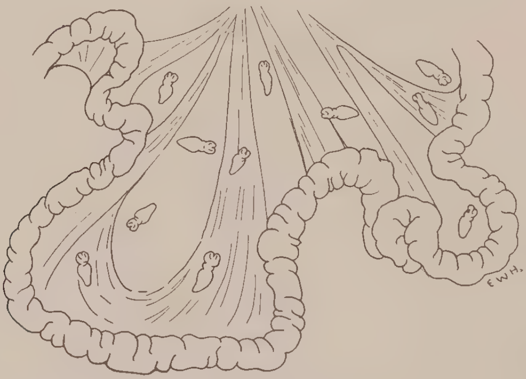

FIG. 222.—Rabbit mesentery, showing bladder worms of serrated dog tapeworm.

The Tapeworms of Cats and Dogs.—Cats and dogs are the primary hosts of a large number of tapeworms. Kittens and puppies (Fig. 222) are often seriously damaged by these worms. In addition these animals harbor a number of tapeworms that are also found in man. Care should be taken, therefore, to see that children are not allowed to handle cats and dogs too freely.

The Tapeworms of Other Domestic Animals.—The ruminants like the sheep and the cow are frequently infected with tapeworms. These worms are especially abundant in the sheep. In addition, the sheep in the Rocky Mountain States are much troubled by the so-called gidworm (Fig. 223), which is the larval stage of a common tapeworm of the dog and other carnivora in that region. The gidworm attacks the brain and spinal cord of the sheep and does not seem to be able to develop completely in any other organ. The bladders on the brain may reach a diameter of several inches and are usually quickly fatal to the sheep. The obvious remedy is to prevent dogs and other carnivorous animals from eating the heads of sheep that have died from gidworms, and to prevent dogs that are infected with the gid tapeworm from running on pastures. If infected dogs are allowed to run on pastures they will deposit proglottids containing eggs which may be eaten by the sheep, thus leading to the development of gidworms on the brain of the sheep.

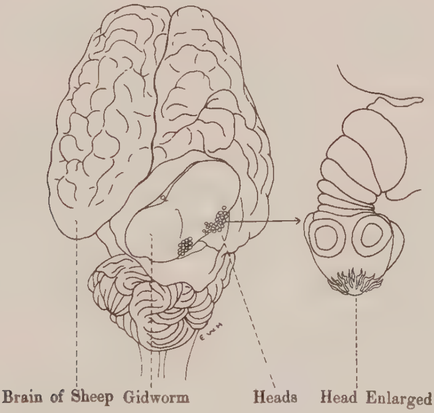

FIG. 223.—Brain of sheep, showing gidworm.

The Tapeworms of Domestic Fowls.—Domestic fowls, especially ducks, geese and chickens, are quite commonly infested with tapeworms. The annual loss of young domestic fowls is undoubtedly considerably augmented by the presence of these parasites. The life histories of the tapeworms of the chicken are not well understood, and that makes them all the more difficult to control. The larval stages of the forms infesting the ducks and geese are passed in minute crustacea, water fleas, which live in the drinking water. Overcrowding of birds should be avoided, thus reducing the danger of soil pollution.

CHAPTER XIV.

SOME ANIMALS OF UNCERTAIN RELATIONSHIP OR OF LITTLE ECONOMIC IMPORTANCE.

- Phylum Cœlenterata
  - Structure
  - Metagenesis
  - Polymorphism
  - Regeneration
  - Coral and coral islands
  - Some common and interesting Cœlenterates
- Phylum Ctenophora
- Phylum Rotifera
- Phylum Bryozoa
- Phylum Brachiopoda

PHYLUM CŒLENTERATA.

This phylum includes about 4500 different kinds of aquatic animals, the vast majority of which are marine. Only a very few species live in fresh water. There are two distinct kinds of individuals in the cœlenterates, the polyps or hydroids (Fig. 224) and the jelly fish or medusoid individuals (Fig. 227). The polyps are usually small as individuals and escape notice unless they form colonies, in which case they are usually mistaken for seaweeds, or if they deposit coral, the skeleton is often conspicuous. Many jelly fishes are small, but some reach a considerable size, several feet in diameter. As they are frequently washed ashore, they are familiar to people who visit the beaches. The jelly fishes are familiar in another way, as all forms are provided with stinging

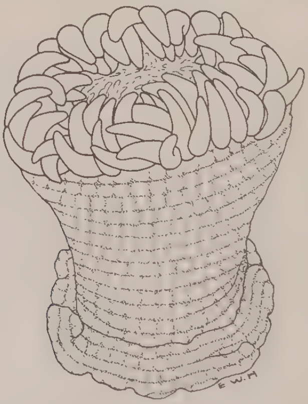

Fig. 224.—A sea anemone. *Metridium sp.*

cells. They may be very annoying to bathers on sea beaches who come in contact with them. These forms are known as "sea nettles."

All of the cœlenterates are radially symmetrical, thus differing from the majority of the Metazoa, which are bilaterally symmetrical. The cells of the cœlenterates are arranged in two definite layers, an outer ectoderm and an inner layer or entoderm, lining the gastrovascular cavity. The space between these two cellular layers is filled with a non-cellular layer, the mesoglœa. The gastrovascular cavity (enteron) is, as its name implies, a cavity that is concerned with the digestion of the food and its transportation to the cells. This cavity has but a single opening, the mouth. The Cœlenterata are also provided with stinging threads for protection against the enemies and for paralyzing their prey. These structures are hollow capsules containing a long, coiled, thread-like tube which is discharged if the proper stimulus is applied to the trigger. Some of the stinging threads seem to be capable of penetrating the bodies of the prey and paralyzing them by the injection of a poison; others seem to coil themselves about hairs or spines on the prey and hold it thus until it can be swallowed.

Reproduction may be by means of lateral budding, in which the new individual appears first as a wart-like outgrowth of the body wall of the parent individual. This outgrowth develops until it resembles the parent form. After development is completed the new individual may become detached to lead an independent existence or it may remain attached to form the second member of a colony of individuals. Succeeding members of the colony are formed in the same manner.

Sexual reproduction also occurs in most forms. Ova and sperms are produced; a single sperm unites with an ovum and the fertilized egg thus produced develops into a larva which forms a new individual. In a few forms fission or longitudinal division occurs. A few forms reproduce by means of transverse division or strobilation.

Metagenesis.—One of the most interesting features of the cœlenterates is the alternation of a non-sexual generation reproducing by means of budding with a sexual generation, reproducing by means of fertilized eggs, which occurs in a number of forms. This process is further complicated by the fact that the non-sexual generation is a hydroid and the sexual generation is usually a medusoid. A very interesting series has been traced from a form like the *Hydra*, where there is no medusa; through forms like the *Sertularia*, where the medusoid form is small and relatively unimportant; to forms like *Obelia*, where the hydroid and medusoid forms are of about equal importance; to forms like *Liriope*, where the hydroid form is reduced; finally, to forms like *Geryonia*, where the hydroid forms have been eliminated.

Polymorphism.—Another interesting feature of the Cœlenterata is the development of the colonial forms with the associated feature of polymorphism (Fig. 225). In some forms the colony is composed of similar hydroids. Just such a colony as would be formed if the new buds that were formed should remain attached to the parent.

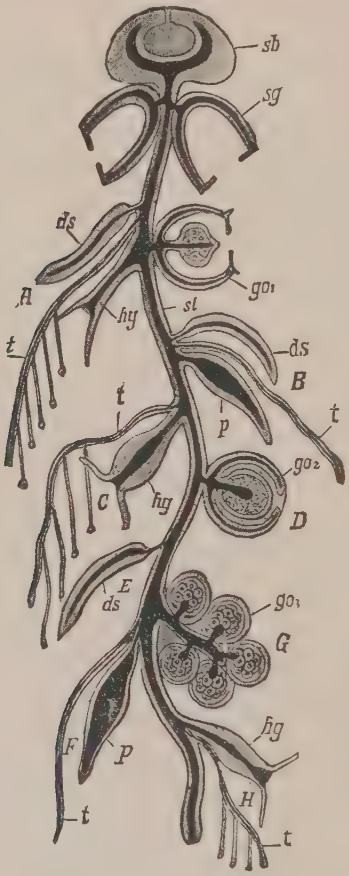

Fig. 225.—Diagram of *Siphonophore* (from Lang). *A H*, groups of different individuals; *ds*, covering scales; *go*, gonophores; *hy*, feeding polyps; *p*, "feelers" (digestive); *sb*, float; *sg*, swimming bell (nectocalyx; *st*, stalk). (From Hertwig's Manual of Zoölogy; courtesy of Henry Holt & Co.)

In such a colony there is usually developed certin hydroids, the reproductive members of the colony that produce medusæ which become sexually mature and produce either sperms or ova, which unite to form the fertilized egg. From the fertilized egg a larva develops, which if successful in finding a suitable location develops into a new colony. In other forms certain individuals are set aside for capturing the prey and another set for digesting it. Thus we have the beginning of polymorphism which reaches its highest development among the tube-like jelly fishes (Siphonophora). In the most elaborate of these colonial forms there may be special individuals set aside as floats, consisting of a bladder-like structure, containing a gas which supports the colony at the surface. Certain individuals are locomotory in functions and by their rythmatic contractions propel the colony through the water. Other individuals are reduced to digestive forms, having as their function the digestion of the food. Still other members of the colony are elongate tentacles provided with numerous, especially large and powerful, stinging threads. Their function is to protect the colony against its enemies and to paralyze and overcome their prey. Sometimes there are scale-like protective individuals which cover and protect the more delicate individuals of the colony. Lastly, there are reproductive members which produce the sex cells for the reproduction of the colony.

Regeneration.—The Cœlenterates possess the power of regeneration to a remarkable degree. *Morphological regeneration* may be defined as the power possessed by organisms of replacing lost parts or the ability of a part of an organism to develop into a complete organism. For example, it has been shown that if a tentacle of a hydra is clipped off a new tentacle will develop to take its place. Or if a hydra be cut into a number of pieces, each piece will grow into a complete individual. Morphological regeneration is generally confined to the invertebrates and is more important in the forms where differentiation of tissues and organs has not reached a very high degree of specialization. *Histological regeneration* may be defined as the power possessed by tissues to repair the wastes produced by vital activities. This repair is effected by the development of new cells. Histological regeneration occurs constantly in the bodies of even the highest vertebrates. Red blood corpuscles are constantly being destroyed and replaced by new cells. The outer layers of the skin are constantly being worn away and replaced by new cells from the deeper layers of the skin. Minor cuts and abrasions are healed by regeneration of the cells of the muscles and skin.

Coral.—Coral is the calcareous skeleton of colonial Cœlenterates. It exists in a variety of forms, sometimes branching and plant-like, sometimes feather-like, sometimes fan-like and sometimes spherical or hemispherical with elaborately ridged surfaces like a brain. Coral is often beautifully colored, especially the so-called precious coral which is usually some shade of red. It is much used for jewelry, and the price varies with the size of the pieces, the shade and purity of color and freedom from blemishes. The finest precious coral stones come from the Mediterranean Sea.

Corals also form coral islands in the warmer parts of the oceans, such as the Bahama Islands, the Fiji Islands, Bermuda, Australia, Cuba, Hawaii, Florida and Yucatan. Coral islands are built on broad submarine banks which are not over 100 to 150 feet deep. On these banks, if conditions are favorable, the coral grows rapidly, and as it approaches the surface of the sea, fragments large and small are broken from the mass of growing coral and piled on top of it. The coral island may be built above the action of the waves. The action of the waves grind part of the coral to sand. This sand may be hardened into soft coral rock which is broken up by the action of the waves and the erosion of the heavy tropical rains. In this way the débris is constantly being piled up and worn down. To this débris other floating material from the ocean is being added. Eventually the seeds of plants floating by are caught in the débris. They germinate and aid materially in holding other floating material from the sea. Thus small or even large coral islands are built up. Coral islands may be new or may be old. The former are still in the process of formation, and consist for the most part of low-lying reefs, composed of sand, fragments of coral, half-formed coral rock and other débris. The "keys" fringing the coast of Florida are examples. The old islands were formed long ago and are now being eroded by the destructive action of the waves and the ocean currents. The Bahamas are an excellent example.

Coral islands being built upon submerged banks, usually occur as narrow reefs near the land. Such reefs may be separated from the land by a broad channel and are called barrier reefs. The Great Barrier Reef, fringing the coast of Australia for more than 1000 miles, is an excellent example. If the reef is not separated from the land it is known as a fringing reef. Atolls are coral reefs with irregular circular outlines surrounding a central lagoon. Atolls are common in the Pacific Ocean. Their curious shape has excited the interest of a large number of observers and there are several theories to account for their ring-like character. According to one theory, this shape is the result of the interaction of ocean currents and waves. According to another theory, these atolls were formed as fringing reefs around a circular or nearly circular volcanic island which later subsided or was washed away by erosion.

The caves and grottos of coral reefs which communicate with the ocean form excellent retreats for fishes, crabs and other marine animals. The animal life of coral reefs is usually abundant and some of the most grotesque and brilliantly colored animals of the sea live in coral reefs.

Some Common Cœlenterata.—The Phylum Cœlenterata is usually divided into three classes, the *Hydrozoa*, *Scyphozoa* and *Anthozoa*.

The Hydrozoa.—The Hydrozoa are cœlenterates with solitary or colonial polyps. If an alternation of generations occurs the polyp is usually more conspicuous than the jelly-fish stage.

The common fresh water Hydra (Fig. 226) may be taken as an example of the solitary fresh water Hydrozoa. They are usually about ½ inch long, but may extend themselves to a much greater length. They resemble bits of slender cord with one end frayed out into short strands; these represent the tentacles, the unfrayed cord representing the body of the animal. The body is cylindric and is attached by a disk to some firm support. The tentacles vary in number, from four to six and eight or more. The mouth lies in the center of the tentacles and leads directly into the gastrovascular cavity. These animals feed on various minute aquatic animals which are captured by the tentacles. Hydra reproduces by budding and by sex cells.

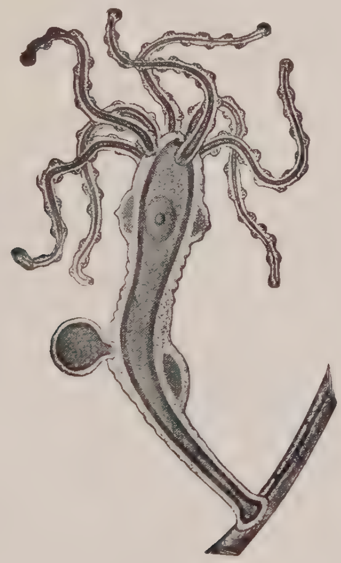

FIG. 226.—*Hydra viridis.* Testes above; ovarian enlargement and escaping eggs below. (From Hertwig's Manual of Zoölogy; courtesy of Henry Holt & Co.)

Many of the marine Hydrozoa are colonial, forming seaweed-like branching colonies attached to rocks, piles, marine plants, etc. The polyps are at the end of the branches in some forms, while in other forms they are borne along the sides of the lateral branches. In some forms there is an encrusting, root-like stem from which the polyps arise as solitary individuals. Most of these animals are mistaken for seaweeds, but a microscopic examination will reveal their true nature. Many of these forms are very beautiful, resembling the fronds of ferns, while others are distinctly feather-like in appearance.

The medusoid forms that belong to the Hydrozoa are usually small, 1 inch or less in diameter, umbrella- or bell-shaped animals with a fringe of short tentacles around the margin. A few of the medusoid forms are larger, sometimes nearly 1 foot in diameter. A few of the Hydrozoa secrete a calcareous skeleton or coral. A common example is the elk-horn coral, or pepper coral, of Florida and the West Indies. It grows in broad, flat, lobe-like branching colonies, hence the name elk-horn coral. It has powerful stinging threads, hence the name pepper corals. If the surface of the coral be examined carefully it will be noted that it is pierced by large pores which are surrounded by a circle of smaller pores. The large pores indicate where the nutritive polyps lived. The smaller pores were occupied by the slender guard polyps which are abundantly supplied with stinging threads.

The most interesting of the Hydrozoa are the free-swimming medusoid colonies. The various types of individuals in a colony have already been discussed under Polymorphism. One of this group is the Portuguese man-of-war. This colonial animal is an inhabitant of the warmer parts of the ocean, but is often carried to our shores by ocean currents and waves. It consists of a large float bearing numerous polymorphic individuals on the lower surface.

In some forms, *Cupulita* and *Agalma*, there is a central axis with two rows of swimming medusoids at one end. Below these there are polymorphic medusoids. Scattered among these medusoids are long tentacles which capture the food.

In *Physophora* the stem is short, bearing several swimming medusoids. The stem is expanded at the lower end into numerous finger-like processes which bear the other individuals of the colony.

Scyphozoa.—In the class Scyphozoa the medusoid forms are more important than the polyp forms. Some of the forms are small, but many are large. One of the commonest jelly fishes along the Atlantic Coast is *Aurelia aurita*. This is a circular flatish medusoid, often 1 foot or more in diameter, with numerous short tentacles. These tentacles are arranged in eight groups, the groups being separated by eight marginal sense organs. The gastrovascular cavity is very elaborate and much branched.

The sea blubber, *Cyanea*, is one of the largest of the jelly fishes, the disk usually 1 foot or more in diameter and the tentacles several feet in length. Individuals 6 or 7 feet in diameter with tentacles 40 feet long have been seen.

The *Pelagia cyanella* is a small jelly fish about 2 inches in diameter with eight long tentacles and four fringed oral lobes surrounding the mouth.

The root-mouth jelly fishes have no tentacles (Fig. 227). There are eight sense organs around the margin and eight large, much-branched oral lobes with numerous sucking disks.

Anthozoa.—The class Anthozoa includes the sea anemones, sea fans, sea pens and corals. All the forms in this class are solitary or colonial polyps. They are usually cylindric in form with one end, the disk or foot, attached to some support and the opposite or oral end free with a number of hollow tentacles surrounding the mouth. Internally the gastrovascular cavity is divided into a number of separate chambers by the mesenteries, which are usually arranged as multiples of six in the sea anemones and corals, or eight in the sea pens, sea fans and related forms.

The sea anemones, *Metridium* (Fig. 224), live abundantly in tidal pools along rocky coasts. They are solitary, cylindric animals with numerous short tentacles around the mouth. They feed on small organisms of all kinds which are captured by means of the stinging theads on the tentacles.

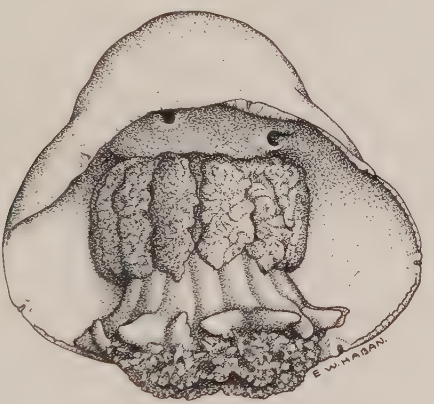

FIG. 227.—Root mouth jelly fish.

The stony corals are colonial Anthozoa which secrete a calcareous skeleton. The skeleton may be hemispherical, mushroom-shaped, branched or tubular in shape. As has been pointed out, they are of importance in building coral islands and reefs in the warmer parts of the ocean. The hemispheric corals are called star corals if they have star-shaped pits on their surface, or brain corals if the surface is covered with irregular grooves. These corals are often several feet in diameter.

One of the commonest of the branching corals is the stag-horn coral. The branches in this coral are cylindric, somewhat tapering and very much roughened. It occurs in Florida and the West Indies, and small fragments are frequently carried considerable distances by currents and waves.

The group which includes the sea pens and sea fans also includes the precious coral. This group has a skeleton of horn-like material with a calcareous crust. The sea fans are broad, much-branched colonial forms with the branches united. The sea feathers and sea pens have a central stalk with the polyps borne on lateral branches.

PHYLUM CTENOPHORA.

This phylum is sometimes considered as a class of the Cœlenterata. It offers, however, certain fundamental differences from the members of the Phylum Cœlenterata. All the forms are delicate, transparent jelly fishes with a spherical or cylindrical, sometimes flattened and ribbon-like body. These forms are usually known as comb jellies, sea marbles or sea walnuts. Some of the forms occur in the ocean in vast numbers, and as they frequently show beautiful colors which combined with their delicate transparent bodies and long tentacles create a great deal of interest. The bodies show two poles, at one pole the mouth, which opens into a complex gastrovascular cavity composed of eight canals. At the opposite pole there is a so-called statocyst which is supposed to be sensory in function. Some of the Ctenophora are provided with two tentacles which may be withdrawn into pits. The tentacles are covered with peculiar "lasso cells," which are provided with adhesive threads that aid in capturing prey. The body is provided with eight meridional bands of cilia which are locomotory in function.

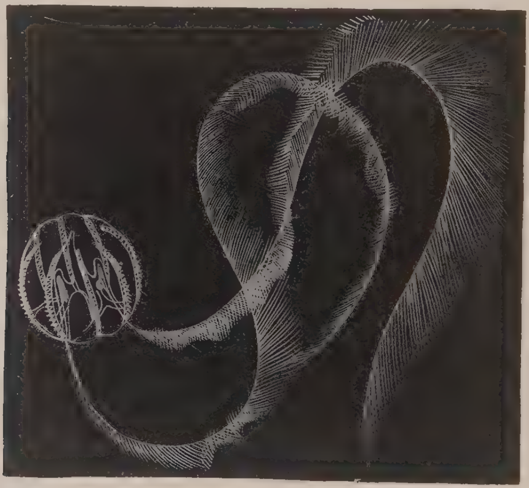

FIG. 228.—Sea marble. *Pleurobrachia rhododactyla.* (From "The Sea-beach at Ebb Tide;" copyright, The Century Company.)

The sea marble, *Pleurobrachia* (Fig. 228), is a delicate, transparent organism of a pinkish color about the size of a marble with two tentacles several inches long, with delicate fringes of long cilia. It is often abundant along the New England Coast.

The sea walnuts, *Bolinopsis* and *Mnemiopsis*, are cylindrical or conical, transparent organisms without tentacles. They often swarm in immense numbers, and as some forms are phosphorescent they make wonderful displays at night.

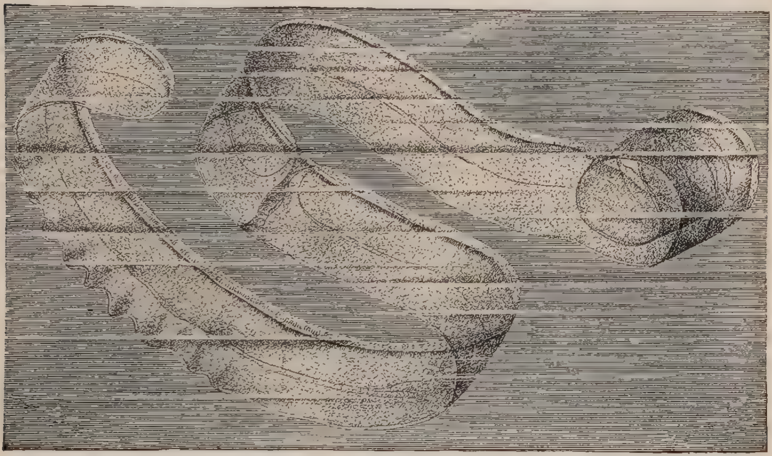

Fig. 229.—Venus' girdle. *Cestus veneris*. (From "Sea-beach at Ebb Tide;" copyright, The Century Company.)

Venus' girdle, *Cestus veneris* (Fig. 229), is an elongate, flattened, ribbon-like animal often several feet long but only 1 or 2 inches in width. The body is very transparent with iridescent colors. This animal is an inhabitant of the warmer parts of the ocean, but is sometimes washed up on our shores.

PHYLUM ROTIFERA.

This is a small phylum of minute aquatic animals, practically all of which live in fresh water, although a few are marine and a few are parasitic (Fig. 230). These animals are generally known as wheel animalcules. Typically the body is divided into a head, a trunk and a foot. The head is provided with a ciliated disk. The movements of these cilia give the appearance of two revolving wheels, hence the name wheel animalcules. The ciliated disk not only aids the animal in swimming, but it propels small animals and particles of food toward the mouth, where they may be passed on into the pharynx and swallowed. The stomach is present and the intestine is a short, straight tube, opening to the exterior through the anus. The head also bears the eyes which vary from one to three in number. The trunk is sometimes enclosed in a shell-like lorica. The foot is often jointed and bears adhesive disks at the tip, by means of which the animal may fasten itself to solid objects. These disks are fastened to solid objects by means of a cement secreted by the cement gland, located in the foot. In this way some of these organisms move about on aquatic plants in a measuring worm fashion.

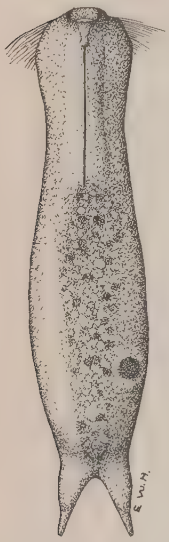
Fig. 230.—Rotifer.

The sexes are distinct, although the males of some species have never been discovered. The males that are known are much smaller than the females. The females in the species that have been studied lay two kinds of eggs—winter eggs, that are fertilized, and summer eggs, that develop without fertilization or parthenogenetically.

Parthenogenesis has been defined as the development of ova or eggs that have not been fertilized. It is of widespread occurrence in the invertebrates, but does not occur in the vertebrates. It occurs not only in the rotifers, as has been mentioned, but also in the worms, in a number of the smaller crustaceans and in a relatively large number of insects, such as certain plant lice, certain scale insects, a few thrips and many bees and wasps. Parthenogenesis may be seasonal, as in the rotifers, that is, occurring during the warm parts of the year, but when cold weather approaches true males and females are produced. The females lay eggs which have been fertilized. These fertilized eggs remain over winter, and in the spring hatch into parthenogenetic females which lay only parthenogenetic eggs, which develop without fertilization. This process may be repeated a number of times during the summer. Many plant lice have a somewhat similar life history, save that here the winter eggs hatch into agamic females that give birth to living young which are likewise agamic females and give birth to living young. Eventually in most species of plant lice the true males and females are produced. These mate and the females lay winter eggs.

In the hive bee, certain wasps and certain ants the fertilized eggs develop into females which may be either undeveloped females, workers or developed females, queens. The parthenogenetic eggs develop into males or drones.

Artificial parthenogenesis may be defined as the development by artificial methods of eggs that are normally fertilized by sperms.

Some of the methods used have been change in temperature, pricking with a fine needle and treating with dilute chemicals of various kinds. By these means the normal eggs of certain worms, molluscs, echinoderms, such as the starfish and sea urchin and the frog, have been caused to develop to relatively late stages. The chief interest in artificial parthenogenesis is not, however, in the fact that eggs have been started on their development, but studies of artificial parthenogenesis have thrown considerable light on the general problems of fertilization and development. In fertilization the sperm contributes not only its share of the heredity characters, but also a stimulus to development which is of primary importance.

PHYLUM BRYOZOA.

This phylum consists of colonial microscopic animals attached to rocks and submerged plants in marine and fresh waters. Some species form under favorable conditions small patches that resemble moss, hence the name Bryozoa, which means moss animals.

PHYLUM BRACHIOPODA.

The members of this phylum are small bivalved marine animals which are attached to rocks and piles. They resemble certain marine clams in general appearance. But there are certain fundamental differences—the shells of the brachiopods are dorsal and ventral, not lateral, as they are in the clams. The animal is provided with a pair of much-coiled tentacular arms which are wanting in the clams. The brachiopods are usually attached while the clams are free-living. Most brachiopods live in shallow water. The brachiopods are interesting also because they have been found in very early rocks as fossils. In fact, many more fossil species are known than living species, about 2500 of the former and only 100 of the latter.

CHAPTER XV.

THE SPONGES AND SPONGE FISHING.

(PHYLUM PORIFERA.)

THE sponges are peculiar plant-like sessile animals whose relations to other groups are not clear. The sponge of commerce is familiar to every one, but, as we shall see, this represents but the skeleton of a single form of sponge, and very few people have actually seen the complete animal, and a knowledge of the other sponges is a closed book to most people, or they may have been observed as objects cast up on the beach during storms.

Structurally sponges are complex organisms. The simplest types may be described as thin-walled vases with numerous pores through which the water is drawn into a large gastric cavity by means of the waving of the flagellated cells. In the gastric cavity the cells absorb and digest the food found in the water. Waste products are returned to the water in the gastric cavity and the water is forced out through the exhalent pore. Such a simple sponge would have an outer protective epithelial layer, an inner gastric epithelial layer and a layer of jelly-like substance containing the skeleton between these two layers. The skeleton is composed of spicules of calcium carbonate or silicon; or spongin or with both spicules of silicon and spongin. Spicules are hard, needle-like pieces of calcarious or silicious material, often arranged in units of three or more needles together. These needles are arranged with reference to each other, so that they support the animal. It is, however, the sponges that have a skeleton of spongin that are chiefly valuable in commerce.

Most sponges are colonial; that is to say, each unit consists of several organisms which have grown together. As a general rule, the number of individual organisms in a colony may be determined by the number of exhalant pores, as there is usually one exhalant pore for each individual. Most sponges are marine. A few forms are found in fresh water forming a jelly-like crust on stones, submerged sticks, the roots of trees and in similar situations.

Reproduction in the sponges is usually by means of buds which may remain attached to the parent organism, thus starting a colony, or the bud may become free from the parent organism and start a new colony. In sexual reproduction both ova and sperms are produced by the same individual. The ovum and sperm unite to form a flagellated larva which swims away from the parent organism, eventually settling down and growing into an adult sponge.

ECONOMIC IMPORTANCE OF SPONGES.

Sponges have been preserved as fossils since Cambrian times. The calcareous spicules have added their bit to the formation of limestone and the siliceous spicules to the formation of flint.

Sponges are also used to a limited extent for ornamental purposes. This is especially true of the glass sponges in which the spicules are very long and fastened together so that they resemble spun glass. The common Venus flower basket belongs to this group and it is doubtful if there is a more beautiful object in nature than the delicate skeleton of this organism, which resembles a delicate open-work vase of intricate pattern, like lace work spun from glass. Glass rope is the stalk of another glass sponge, which is often used for ornament. It consists of long strands of delicate elongate spicules closely wound together in a spiral cord with the lower ends frayed out.

Commercial Sponges.—The commercial sponge owes its value to the delicate silk-like texture of the skeleton which, when properly prepared, is tough and will absorb and retain a large amount of water. It has, therefore, many uses in the arts, in medicine and for toilet purposes, with a value of nearly $5,000,000 each year. Commercial sponges are chiefly inhabitants of the warm seas of the world. Commercial sponges come principally from the Mediterranean and Red Seas, from the east coast of Florida, the Bahamas, the West Indies and Central America. They are collected in a variety of ways in different regions of the world; sometimes by naked divers, who use a weight to descend to the bottom of the ocean, where they remove the sponges from the rocks with their hands; sometimes by men in diving suits; sometimes by dredges; sometimes by men in small boats who use long poles with special hooks on the end. After the sponges are collected they are exposed to the air until decay starts. Then they are placed in tanks of water until decay is complete. The decayed animal is then completely removed from the skeleton by washing and beating. The skeletons are then in the form of the commercial sponge and are ready for the market after they have been sorted and trimmed.

CHAPTER XVI.

THE PROTOZOA AND PROTOZOAL DISEASES.

- THE CHARACTERISTICS OF THE PROTOZOA
- THE CLASSIFICATION OF THE PROTOZOA
  - Sarcodina
  - Sporozoa
  - Mastigophora
  - Infusoria
- DISEASES CAUSED BY PROTOZOA
  - Amœba and amœbic dysentery
  - Amœba and black head of turkeys
  - Plasmodium and malaria
  - Babesia and Texas fever
  - Trypanosoma and African sleeping sickness
  - Nosema and diseases of silkworms and bees
  - Some other diseases that may be of protozoal origin

THE CHARACTERISTICS OF THE PROTOZOA.

The Protozoa are single-celled organisms. A few are colonial, but the cells composing these colonies are usually similar in structure and undifferentiated. Since the Protozoa are single-celled organisms they are rather sharply separated from the Metazoa which are organisms composed of many cells. Yet in spite of the fact that these organisms are composed of but a single cell, the single cell performs all the functions common to many-celled organisms. Hence the structure of the Protozoa is often complex and frequently very complex, for the single cell must perform the essential functions of life, such as metabolism, growth and reproduction.

Most Protozoa are microscopic in size, the larger usually being just barely visible to the unaided eye. A few forms are macroscopic and occasionally forms are found that are nearly 20 mm. in length. On the other hand, many forms are very minute, being just visible with the ordinary or higher powers of the microscope and some forms may exist which are not visible even with the highest powers of the microscope. Because of their very minute size, these animals are without a common name. Occasionally the forms that cause diseases of man or his domestic animals are called "germs," but this is a term that is loosely applied to bacteria and fungi as well, so that it cannot be said to be a name for the parasitic Protozoa. Protozoa are, however, practically universally present in water whether fresh, brackish or marine. Many live in damp soils and quite a large number are parasitic and live within the bodies of other animals.

CLASSIFICATION OF THE PROTOZOA.

The type and arrangement of the locomotor organs is usually used as a basis for the classification of the Protozoa. On this basis there are four classes: The *Sarcodina*, which have *pseudopodia;* the *Sporozoa*, which have no locomotor organs in the adult stage; the *Mastigophora*, which have *flagella;* the *Infusoria*, which have *cilia.*

The Sarcodina.—The Sarcodina are characterized by the presence of temporary lobe-like or strand-like filaments of protoplasm which are the locomotor organs. These are called *pseudopodia* and are used for creeping on the surface of plants or on the bottoms of pools, or for swimming about in the water.

Some of the forms are without shells (Amœba), but many of the forms both in fresh and marine waters have shells (Arcella difflugia) (Fig. 231). There are two general types of marine shells, the Foraminifera which may have shells of lime (fossil Foraminifera form great beds of chalk and limestone in certain regions of the world), and the Radiolaria, which may have shells composed of silicates and their fossilized shells form layers of flint.

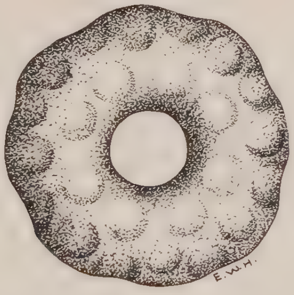

FIG. 231.—Shell of *Arcella.*

Sporozoa.—The Sporozoa are all parasitic forms without locomotor organs. They live within the cavities of the body or in the cells or tissues of various organs of the body of certain animals. When an animal lives thus on or in the body of another animal obtaining its food from the body of this animal, it is called a *parasite*, and the animal on which it lives is called the *host.* Since the Sporozoa are without locomotor organs they are usually dependent upon other animals for transporation from one host to another. The animals which carry these parasites are known as *carriers* if they simply transport the parasite from one host to another. In many cases the parasite lives for part of its life cycle on or at the expense of the animal that transports it. This animal is then called a *secondary host.* Leeches, ticks and insects, especially blood-sucking insects, are frequently secondary hosts for Sporozoa. Because of the various interrelations of host and parasite and parasite and secondary host, the life history of a sporozoan is often very complicated, and in some of the forms our knowledge of these interrelations is still incomplete. Some Sporozoa have but a single host, in which case they are spread from host to host through infested food or water. Sporozoa of various kinds are parasitic on a long list of animals. Some forms cause serious diseases of man and domestic animals.

Mastigophora.—The animals of this class are characterized (Fig. 232) by the presence of one, sometimes two or several long, whip-like locomotor organs called flagella. Many of the Mastigophora are free-living forms and they are frequently abundant in stagnant water (Mastigamæba, Euglena). Some forms are marine, one of which is phosphorescent, Noctiluca. This form is often abundant in tropical and sub-tropical seas, producing light when disturbed, so that the crest of each wave or the wake of a ship is brilliantly illuminated. The sand of the beach becomes saturated with these minute animals, so that one may leave his footprints or write his name in living fire. Some flagellates are parasitic and cause serious diseases of man and his domestic animals.

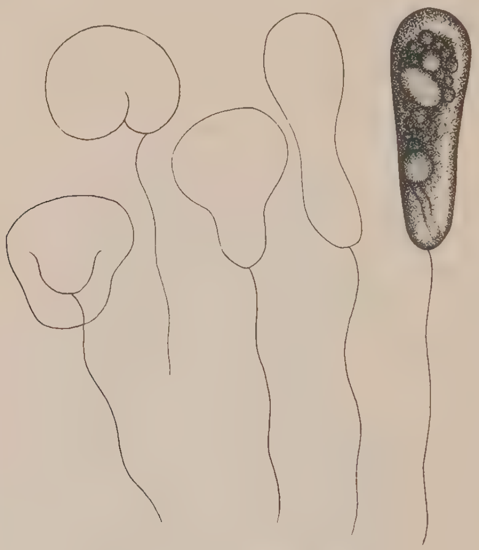

FIG. 232.—*Peranema spp.*

Infusoria.—The Infusoria have numerous short hair-like locomotor organs called cilia. The Infusoria are usually abundant wherever stagnant water occurs. Most of the forms are free-living

Paramecium, Spirostomum (Fig. 233), Stylonychia, Vorticella (Fig. 234), but a few forms are parasitic.

The Protozoa in General.—Having discussed the general features of the various classes of the Protozoa, there are still some general considerations which may be discussed before we describe the Protozoa which cause diseases.

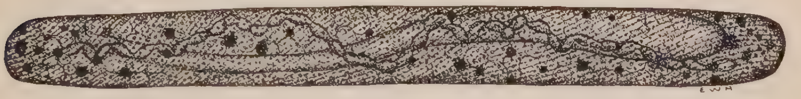

FIG. 233.—*Spirostomum.*

Behavior.—The behavior of the Protozoa has long been a favorite study of microscopists. While certain features of their behavior seem to be of the order of simple tropisms, that is, direct and invariable responses to certain stimuli. Jennings and others contend that much of the behavior of Protozoa can be explained better on the basis of trial and error. That is, the organism makes an adjustment to a stimulus which it tries, and, if in error, makes further adjustments until the proper results are obtained.

Metabolism.—The processes of metabolism are much simplified in the Protozoa. Ingestion may take place anywhere on the body surface, as in Amœba, or it may occur only through a definite groove which leads to a buccal cavity and gullet as in Paramecium. In many parasitic Protozoa ingestion apparently takes place directly through the process of osmosis. Digestion usually takes place in so-called food vacuoles, which are apparently masses of food surrounded by a digestive fluid. Certain forms, such as Euglena, are green in color, due perhaps to a substance similar to, if not identical with, chlorophyll which in the green plants is able, in the presence of light, to combine the carbon in carbon dioxide with water and produce carbohydrates like starches. Respiration occurs directly either from the free oxygen contained in the water, which is the habitat of the free-living forms, or from oxygen supplied by the respiratory apparatus of the host in the parasitic forms. Excretion occurs through the surface of the body of the organism and also through the *contractile vacuoles* which seem to eliminate liquid wastes.

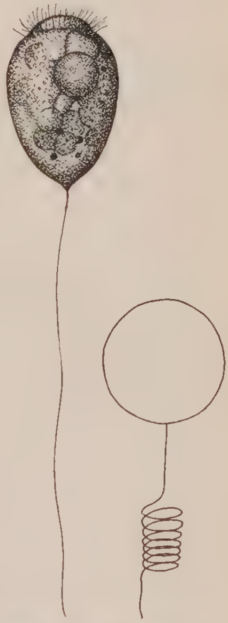

FIG. 234.—*Vorticella.*

Reproduction.—While most Protozoa reproduce by simple *binary division* or *fission*, in which the parent organism simply divides into two organisms, the process of reproduction is often complicated by *conjugation*, *gemmation* or *sporulation*, together with *zygote* formation. The relation of these processes to fertilization is not clearly understood in all cases. Our knowledge of the life history of any given species is rather fragmentary. In conjugation there is an

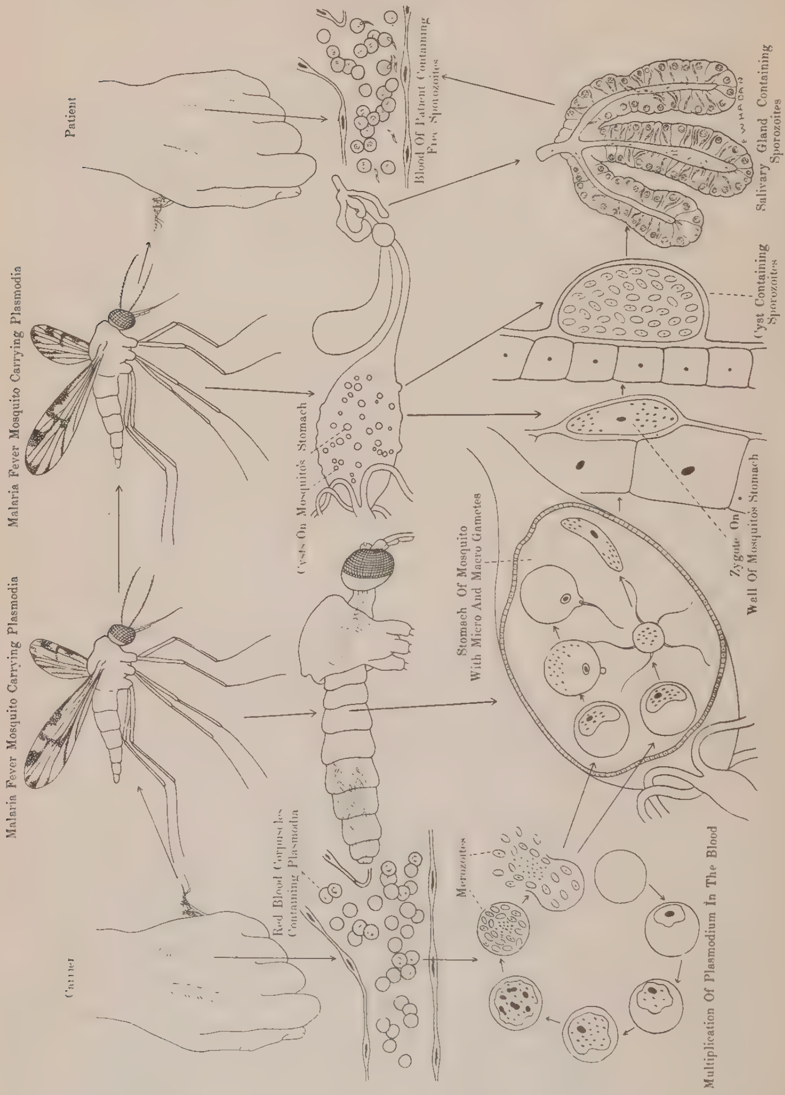
Patient
Malaria Fever Mosquito Carrying Plasmodia
Malaria Fever Mosquito Carrying Plasmodia
Blood Of Patient Containing Free Sporozoites
Salivary Gland Containing Sporozoites
Cyst Containing Sporozoites
Cysts On Mosquito's Stomach
Stomach Of Mosquito With Micro And Macro Gametes
Zygote On Wall Of Mosquito's Stomach
Red Blood Corpuscles Containing Plasmodia
Merozoites
Carrier
Multiplication Of Plasmodium In The Blood

FIG. 235.—Diagram of the life cycle of the malaria fever parasite.

exchange of nuclear material between two individuals followed by fission; but the stimuli which cause conjugation or the physiological significance of this process is not known. The term gemmation or multiple fission may be used for those cases where the parent organism encysts and then divides by successive divisions into a number of *gemmules*. When the encysted gemmules reach a favorable environment, the cysts disintegrate and the gemmules produce new individuals.

The term sporulation (Fig. 235) may then be retained for the type of reproduction in the class Sporozoa in which asexual multiple fission is followed by *gamete* formation and the gametes fuse to form a *zygote*. All the Sporozoa produce spores which are fragments of the parent form in an encysted condition. These little cysts are enclosed in a covering which enables them to withstand adverse conditions and which dissolves when they gain entrance into a host, thus liberating the organisms. This form is known as a trophozoite because it lives at the expense of the host. The trophozoite multiplies, often very rapidly, by fission, producing merozoites which develop into trophozoites, which also grow at the expense of the host and multiply by fission or schizogony. The process of schizogony may continue as long as the host lives. Large numbers of trophozoites may be produced in this way, and their presence in the host may set up a serious disturbance or disease, which in many cases may prove fatal to the host.

Schizogony is always followed by sporogony. This process leads to the formation of spores which are transmitted to a new host. Sporogony is usually further complicated by a gametic phase in which two types of gametes are produced, small microgametes and larger macrogametes. A single microgamete fuses with a macrogamete to produce a zygote. This zygote may grow at the expense of the secondary host and by the process of fission produce numerous spores which may be carried back to the primary host.

DISEASES CAUSED BY PROTOZOA.

Many diseases of man and animals are caused by Protozoa. For the most part, these diseases are more prevalent in tropical and the warm temperate regions of the globe. Frequently these diseases are of such importance that they hinder the development of whole regions, as witness sleeping sickness in Africa and malaria and yellow fever in Panama. We will have space here for only a very brief consideration of some of the more important of these diseases.

Amœbic Dysentery.—This is a dread and often fatal disease of man which occurs, especially in the Oriental region. This Amœba attacks the wall of the intestine causing ulcers. From the intestine it is carried to the liver, where it causes liver abscesses. Infection is usually direct through food or drinking water contaminated with fecal matter, containing encysted Amœba.

Several other Amœbæ have been found in man (the colon Amœba is especially common in the large intestine), but so far as is known these Protozoa produce no disease.

Black Head of Turkeys.—This important disease of turkeys is caused by a small protozoan, Amœba or Flagellate, which lives in the cecum and liver. It is especially fatal to young birds, but is carried by the old birds from year to year. The combs, wattles and bare skin of the head and neck turn dark, hence the name black head. When the birds are attacked they loose their appetites, diarrhea sets in, the birds become weak and not infrequently death occurs within twenty-four hours. The best method of prevention is to allow the turkeys free range over a considerable area, thus reducing the chances of infection.

Certain of the tumors of domestic animals, especially the horse, contain Amœbæ, but whether these Protozoa cause the tumors or are simply accidental inclusions has not been clearly established.

Malarial Fever.—This common disease of man is known under a variety of names, such as chills, chills and fever, the fever, etc. It is one of the most troublesome of human diseases, not because it is so very fatal, but because it incapacitates so many people who live in the tropical and warm temperate regions of the earth. Yet in spite of the fact that it does not kill a high percentage of the persons infected, malarial fever stands near the head of the list of the deadly diseases of mankind. It is said to be responsible for one-half of the mortality of the world.

Malarial fever is caused by three different species of the genus *Plasmodium.* These minute Protozoa live in the blood of man and destroy the red blood cells. When one of these parasites gains entrance into a red blood cell it grows at the expense of the blood cell and soon divides and divides again until several, usually 8 to 24 merozoites are formed. While this multiplication is going on the fever is rising. When the division is complete the merozoites are thrown out into the blood stream and a chill is produced. This chill is produced perhaps by a chemical substance called hematin produced by the destruction of the hemoglobin of the red blood cells. Since this multiplication period is very regular for each species of Plasmodium the alternate chills and fever are regular. Thus, in the estivo-autumnal fever usually every twenty-four hours, in the tertian fever every forty-eight hours and in the quartan fever every seventy-two hours.

So far as is known, the malarial fever parasite can be transmitted from one person to another only through the bite of the malarial fever mosquito (Fig. 235). In order for a mosquito to infect a person, that individual mosquito must have previously bitten a person having the malarial fever parasites in the sexual stages. These sexual stages enter the stomach of the mosquito, where a single microgamete unites with a macrogamete to form a zygote which bores its way through the wall of the mosquito's stomach and forms a cyst, the oöcyst, on the outside of the mosquito's stomach. Inside the cyst the zygote divides until a large number of sporozoites are formed, which find their way to the salivary glands and are ready to be injected into a new host when the mosquito bites. This process requires from one to two weeks, so that this period of time must elapse before a malarial fever mosquito can transmit the malarial fever parasite.

Because of the relations of the malarial fever parasite to its primary host and secondary host, there is established what may be called a malarial chain, consisting of these links; the carrier, or person having malaria, the mosquito and the patient or person that will acquire the malarial parasite from the mosquito. Obviously this chain may be broken in a number of places. We might screen the mosquito away from the carrier or the patient. If we could require all the carriers or all the patients, or both, to retire to well-screened houses before dusk, there would be no infected mosquitoes and in a short time no malaria. This is just what Grassi did in his famous experiments in Italy, which established beyond a doubt the part that the mosquito plays in transmitting malaria. He brought people from a non-malarial district to a malarial district and those that stayed in well-screened houses at night did not get malaria, while those in unscreened houses did get the disease.

Another place to break the chain is to cure the carriers by killing all the parasites in their blood by the proper use of quinine which is a specific for this disease.

Still another way to break the chain is to reduce the mosquitoes by eliminating their breeding places. This may be done in some localities by drainage. Since the malarial mosquitoes breed in stagnant water, many breeding places can be entirely eliminated by drainage. Pools that cannot be drained may be oiled, thus covering the water with a film of oil which prevents the larval mosquitoes from breathing. Top minnows, which are deadly enemies of mosquitoes, may be introduced into some pools. More recently experiments have been carried on using poisons dusted over wide areas from an aëroplane. These experiments promise much for mosquito control, especially in sparsely settled areas. In any mosquito campaign it is well to remember that from the standpoint of malarial fever control it is only necessary to reduce the number of malarial mosquitoes in a given region. Thus, it has been shown that a reduction of the number of malarial mosquitoes from an average of 60 per person to an average of 40 per person, practically eliminates malarial fever. The complete extermination of the malarial fever mosquito is not yet possible, but its practical reduction is possible in many regions.

The last link in the chain which may be broken is to prevent the patient from acquiring malaria. This may be done by proper protection from malarial mosquitoes, by screens and also by the proper use of quinine. This latter method is especially advisable for persons who are going from a non-malarial region to a malarial region. The amount of quinine and the frequency of the dose should always be determined by a physician.

Other plasmodium-like parasites are found in the pigeon. These parasites seem to be transmitted by mosquitoes of the genus *Culex* in one case and in another case by the bite of the winged fly called a bird tick.

Texas Fever.—This disease of cattle is caused by a sporozoan parasite which destroys the red blood corpuscles. Since its secondary host is a tick, the disease is sometimes known as "tick fever." This disease is also called red-water fever because the urine is colored red by the red blood corpuscles which have been destroyed by the parasite. This is one of the most important diseases of cattle in the Southern States. Several years ago a quarantine was established against this disease which prohibited the moving of cattle beyond this line. This quarantine line has been gradually moved South and East as cattle ticks and the disease have been eliminated from a given area. In this way about 90 per cent of the area that was formerly infested with Texas fever has been freed from this disease.

The symptoms of the disease are rapid increase of temperature, often as high as 105° to 106° F., and a discoloration of the urine which becomes reddish or dark colored. Sometimes the animal loses its appetite, loses weight, becomes weak and emaciated and will not fatten, and the milk production is reduced. In some cases the animal dies. The number of red blood corpuscles in the blood may be reduced from a normal average, 7,000,000 per 1 c.ml., to less than 1,000,000 per 1 c.ml.

As has been intimated, the disease is caused by a small protozoan, Babesia, which lives in the red blood corpuscles. This parasite is usually found in the blood cell in the form of two pear-shaped or spherical bodies lying close together. The life history is not completely known, but it is known that the parasite is transmitted from cow to cow by means of the cattle tick. Since the cattle tick is not in the habit of wandering from host to host, the parasite is transmitted through the egg stage of the tick. When the adult female tick lays eggs she places a small drop of blood in each egg. If this blood comes from a cow that is infected with Texas fever the larva that hatches from this egg is infected and is capable of transmitting the fever. If the larva gets on an animal that is not infected with fever, the parasite will be injected into the blood by the bite of the tick. When the female nymphs become full grown they will drop off the host and lay eggs which will produce infected larvæ.

The methods of control which have been used so successfully against this pest are the quarantine, freeing the cattle in the quarantined area of ticks by dipping or spraying with arsenical solution, or by using a long rotation of pastures so that all the larvæ which have hatched from infected eggs in a given field will die before the cattle are returned to that field.

There are also other species of Babesia, which produce a somewhat similar disease of the sheep in the Mediterranean region, of the dog in Africa and Southern Europe and of the horse in South Africa, parts of Europe and Asia. So far as is known, all these species are transmitted by the bites of ticks.

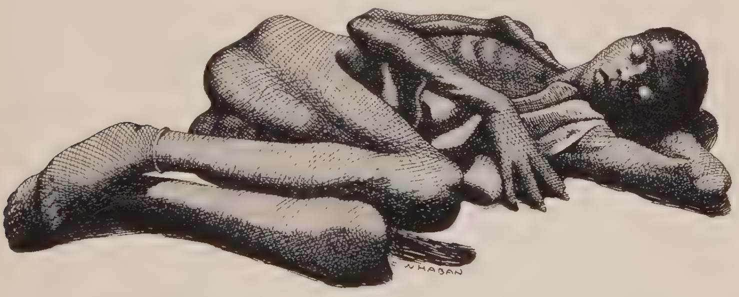

FIG. 236.—Sleeping sickness patient in coma. (Redrawn from photograph.)

Sleeping Sickness.—This is the most important disease of man caused by *Flagellates*. This disease, which is caused by a trypanosome, is transmitted by the bite of the tsetse fly and is limited to that area in Africa where this fly is found. The parasite lives free in the blood stream and collects in the liver, spleen, lymph glands, etc. In the final stages it usually penetrates into the brain cavity itself. The symptoms of the disease are loss of appetite, extreme emaciation passing to coma (Fig. 236) and ending in death, usually within three or four months.

The control of the disease is complicated by the fact that certain wild animals, such as the antelope, may act as reservoirs or carriers of the parasite. The disease is 100 per cent fatal, but recent experiments seem to indicate that arsphenamine or some of the closely related arsenical compounds may be specifics against this parasite.

Chagas' Disease.—Another trypanosome causes Chagas' disease in Brazil. This disease is transmitted through the bite of Triatoma, one of the true bugs closely related to our common blood-sucking bug that is known as the "kissing bug." This disease not only affects man, but monkeys and guinea-pigs are also affected. It is especially bad among young children who cannot protect themselves against the bite of the bug. The parasites seem to attack the heart muscles in particular and in the chronic form leads to retarded mental and physical development.

Nagana.—Trypanosomes also cause important diseases of animals, such as nagana, which occurs in East Africa generally. It might be called the sleeping sickness of the domestic animals, as the symptoms are similar to African sleeping sickness, and it is also transmitted by the bite of a tsetse fly. It is especially fatal to the horse, ass, mule and dog, but also attacks other domestic animals.

Dourine.—Dourine is a sexual disease of the horse, often called the syphilis of the horse, which is caused by a trypanosome. It is found in the western United States, in the Mediterranean region and in various parts of Europe. It is transmitted directly during coitus.

Surra.—Surra is a disease of horses, cattle, camels, dogs and elephants caused by a trypanosome. It is found rather generally in Asia. It is transmitted by the bite of one of the horseflies (Tabanidæ) and perhaps by the bites of other blood-sucking flies, such as the stable fly (Stomoxys).

There are also several other diseases of domestic animals caused by trypanosomes, but they are only of local importance. The spirochetes and their allies are flagellated organisms, now usually classified among the bacteria. But in their structure and behavior they are so similar to trypanosomes that they are mentioned here. The spirochetes and their allies cause such important diseases of man, as recurrent fever transmitted by the bedbug; syphilis, one of the dread venereal diseases, transmitted by direct contact or to the developing fetus through the blood of the infected mother; yellow fever, transmitted by the yellow fever mosquito. Yellow fever was formerly one of the dread diseases of tropical countries, but since the discovery of the relation between the disease and the mosquito the disease has been reduced until it is relatively of minor importance only.

Nosema Disease of Bees.—This disease of adult bees is caused by a species of Nosema which attacks the lining of the stomach. Infection is direct from diseased to healthy bees. This disease results in the gradual dwindling of adults in the colony, although the colony does not usually die out completely.

Pebrine, or silkworm disease, is a contagious and infectious disease of silkworms which is very fatal. The germ of this disease is a protozoan, belonging to the genus Nosema. The control methods devised by Pasteur are still in use. This consists of a microscopic examination of the female moth after she has laid her eggs and the destruction of all eggs from infected females.

Some Other Diseases That May Be of Protozoal Origin.—There is a long list of human diseases which are quite similar in general symptoms or methods of transmission to protozoal diseases that are believed to be of protozoal origin, although the specific organisms of these diseases are not known or only imperfectly known at the present time. This list includes such diseases as Rocky Mountain spotted fever, transmitted by the Rocky Mountain spotted-fever tick, a very fatal disease of man in certain valleys of the Rocky Mountain region; and break-bone fever, a very unpleasant disease of the Southern States, transmitted by the bite of the yellow fever mosquito.

To this list also belong rabies, the cause of mad-dog scares, scarlet fever, smallpox, trachoma, a disease which causes granular inflammation of the eyelids and often leads to blindness, and, last, the dreaded typhus fever.

INDEX.

IN this index important page references are in **black faced type**; pages showing illustrations are preceded by a *; generic names are in *italics;* names of families and higher groups are in SMALL CAPITALS and paragraph headings are in **black faced type.** This index has been made especially full so that it may serve as a glossary.

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